SPINNING STRAW INTO BLACK GOLD: ENHANCED OIL RECOVERY USING CARBON DIOXIDE

OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES

OF THE

COMMITTEE ON NATURAL RESOURCES
U.S. HOUSE OF REPRESENTATIVES

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OVERSIGHT HEARING ON SPINNING STRAW INTO BLACK GOLD: ENHANCED OIL RECOVERY USING CARBON DIOXIDE.

Thursday, June 12, 2008
U.S. House of Representatives
Subcommittee on Energy and Mineral Resources
Committee on Natural Resources
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:08 a.m. in Room 1334, Longworth House Office Building, Hon. Jim Costa [Chairman of the Subcommittee] presiding.

Present: Representatives Costa, Pearce, Holt, Sali, Smith, and Scalise.

STATEMENT OF THE HONORABLE JIM COSTA, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. COSTA. The oversight hearing of the Subcommittee on Energy and Mineral Resources will come to order. The Subcommittee is meeting today to hear testimony on enhanced oil recovery using carbon capture and sequestration. There has been a lot of discussion about this over the last several years, and there is proposed legislation that deals with the issue.

It is appropriate and fitting, therefore, that the Subcommittee take an opportunity to have the various witnesses give us their take on the potential as it relates to a host of options in terms of the management toolbox for carbon sequestration for oil and gas recovery, as to the potential as it relates to carbon capture and sequestration.

I have to do a few preliminaries before I and the Ranking Member get into our opening statements. They are the following.

Under Rule 4(g), the Chairman and the Ranking Minority Member may make opening statements, which I guess we will do. If any Members have any other statements, we are interested in them, and they will be included in the record under unanimous consent.

Additionally, under Committee Rule 4(h), additional material for the record should be submitted by Members or the witnesses within 10 days after the hearing. We ask you to really comply with that, and to help our staff, both the Majority and Minority staff.

We would appreciate witnesses' cooperation in any written submission of questions to the witnesses, either in the first or second

panel, if in fact questions are submitted by Members, that you respond in a timely fashion in writing within the 10 days.

Now, having settled all that, let me begin in terms of an opening statement for all of you here who are present.

We are meeting today obviously to look at what are the current state-of-the-art practices, and what is the potential as it relates to enhanced oil recovery using carbon dioxide. This is one of those energy issues where I think there is agreement on both sides of the aisle, that there are not only current activities taking place, but activities that can be built on.

Not only can this technology help increase our domestic production of oil, but in fact it is already doing an impressive job in many fields throughout the country. And at the same time, the carbon dioxide that otherwise would go out into the atmosphere is being placed where it doesn't have an impact on our air quality.

In my own district, there is a focal point for enhanced oil recovery that really has been taking place for decades. First, for those of you who are not aware of the district that I represent, it goes from Fresno in the north all the way down to Bakersfield in the south. And some of the earliest oil fields in California were developed in the Kern County region.

Since 1961, we have begun a significant effort in taking some of the older fields that were first developed at the turn of the 20th century, some 50, 60 years prior, and in the early sixties we began looking at innovative ways that we could enhance the recovery, and therefore the production, of those older fields.

It first began with steam injection, taking the steam and impacting the viscosity of the thicker crude that was contained in the strata, and using the steam to loosen up that very heavy crude, and getting, in a more cost-effective fashion, the ability to recover that oil. As a result of that effort, that steam recovery, now for over four decades, we have had over 270,000 barrels of oil per day come through many of the older fields in California because of enhanced recovery.

But projects like steam obviously don't use carbon dioxide. And we see an opportunity here to use a new technology that has taken place in a number of areas.

In the last two years there are over 21 new carbon dioxide EOR projects in the United States. I think that is good news for all sorts of reasons. Twenty-one new carbon dioxide EOR projects in the United States.

All told, carbon dioxide EOR produces today in the United States 250,000 barrels of oil each day, which equates to roughly 5 percent of the U.S. oil production. And the potential for additional application, I think, is even greater.

The Department of Energy has estimated that there are over 80 billion barrels of oil in the United States that is amenable to carbon dioxide-enhanced oil recovery, using current technology. Advances in EOR technology, that number could double, it is believed by some to be as much as 160 billion barrels of domestic oil production.

Many of these resources exist in fields that are already in operation, where there is infrastructure, not only including the wells, but including the pipelines and the roads. The infrastructure that

is necessary to make carbon dioxide enhancement recovery work. These resources I think are important to evaluate, and to assess in terms of how we can expand that exploration.

While discussing the benefit to domestic energy supply, we also need to be mindful of the benefit to the environment, because I think it is equally as important. This great example of taking something that is often thought of as a waste product—i.e., carbon dioxide—and using it beneficially I think bodes well for all of us. If we take carbon dioxide from human activities and make sure that it stays underground, we can get some benefits as it impacts the climate.

The International Energy Agency has said that carbon capture and sequestration is critical to reducing carbon dioxide. Enhanced oil recovery can help capture and sequester a lot of carbon dioxide, up to 13 billion tons by some estimates.

Still, the National Petroleum Council has recently put it, "Enhanced oil recovery using carbon dioxide has the potential to play a key role in the early commercialization of carbon capture and sequestration; and as such, will provide an important technology bridge to the extensive application of carbon sequestration."

I agree with that sentiment, and I believe that the future of carbon dioxide-enhanced oil recovery is a bright one, just as back in the sixties the use of steam injection into some of the older fields in Kern County allowed us to take that thick, heavier crude and reduce its viscosity to a point where we could enhance the recovery of those fields.

I look forward to the testimony from our witnesses. And I, at this time, would like to yield to the gentleman from New Mexico, the Ranking Member of the Subcommittee, Mr. Pearce.

[The prepared statement of Mr. Costa follows:]

Statement of The Honorable Jim Costa, Chairman, Subcommittee on Energy and Mineral Resources

In these times of record oil and gas prices, there is near unanimous bipartisan agreement that one of the goals we need to focus on is providing timely relief for American consumers—consumers who are spending higher and higher percentages of their incomes to fill their gas tanks and cool their homes. However, each party has very different ideas about the best ways to accomplish that goal.

I do not believe that either party has a monopoly on good sense when it comes to this issue. Both have ideas that are valid, and that need to be explored. As someone who feels that we need to come together to find common solutions to our energy problems, it is particularly encouraging to be able to find a subject that has so much appeal to both sides of the aisle. Carbon dioxide enhanced oil recovery is a win-win: it has energy supply benefits and it has environmental benefits. Done right, it has the ability to significantly increase the amount of oil we produce domestically, while also acting as a bridge to the large-scale sequestration of carbon dioxide underground, which the International Energy Association has said is essential for reigning in future carbon dioxide emissions.

Enhanced oil recovery (EOR) has a long and lustrous history in my part of California. The oldest operating enhanced oil recovery field in the United States is in Kern County, and after four decades is still injecting steam to produce over 33,000 barrels of oil per day. Traditional oil production only recovers about one-third of the oil originally in the ground, leaving a huge resource base that we would be foolish to ignore. And since those first days in Kern County, steam and carbon dioxide have helped to flush out billions of barrels of additional oil from California to Texas, from the Rockies to the Gulf Coast.

While production from steam EOR has been declining in recent years, carbon dioxide EOR has been growing, to the point where it now produces nearly 250,000 barrels of oil per day, nearly 5% of total United States oil production. And there is plenty left to go after, too. The Department of Energy has estimated that with

current technology, there are over 80 billion barrels of oil in existing fields that could be obtained with carbon dioxide enhanced oil recovery, and with technological advances, that number could double.

Let me say that again: there are over 80 billion barrels of oil in existing fields that could be obtained with carbon dioxide enhanced oil recovery. That is 8 times the amount of oil estimated to be contained in the Alaska National Wildlife Refuge.

But the problem for EOR, ironically, is a lack of carbon dioxide. While there are billion of tons of CO_2 coming out of our power plants each year, we simply do not have the infrastructure in place to capture and direct it to oil fields. Instead, we drill for natural sources of carbon dioxide stored underground, or, to a lesser extent, we capture the carbon dioxide coming off natural gas plants, fertilizer plants, or other small industrial facilities, and then transport it over 3,500 miles of pipeline to get it where it is needed. This is, however, just a small fraction of what we would need to fully unlock the potential of EOR.

There are other environmental benefits to carbon dioxide EOR besides the reduced emissions to the atmosphere. By focusing on those fields that have already been in production, we get to take advantage of existing infrastructure, like wells, pipelines, and roads, as well as ease the pressure to start drilling in new areas.

Enhanced oil recovery will not be the solution to our carbon dioxide emission problem—estimates are that we could store roughly 13 billion tons of carbon dioxide through EOR, but that is not nearly enough. Still, it provides a very strong incentive for power plants to capture and sell their carbon dioxide, and for pipeline operators to build the connections necessary to get the carbon dioxide from the plant to the field. Our ability to reduce emissions in the future may depend on us taking both of these steps, so to the extent that EOR can help get us to do those faster, we are far better off.

As the National Petroleum Council's recent report titled "Facing the Hard Truths about Energy", noted, "enhanced oil recovery using carbon dioxide has the potential to play a key role in the early commercialization of CCS [carbon capture and sequestration] and, as such, will provide an important technology bridge to more extensive carbon sequestration."

I wholeheartedly agree, and I look forward to the testimony from our witnesses.

STATEMENT OF THE HONORABLE STEVAN PEARCE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW MEXICO

Mr. PEARCE. Thank you, Mr. Chairman. I appreciate your holding this hearing today. We are meeting at a time when gas prices are an unprecedented $4.05 a gallon. They are significantly higher in places like California and the District of Columbia.

Every day Americans are paying a record portion of their income in energy costs. But when you go to the poorest states, like New Mexico—we are about 47th on the per capita income—we pay a significantly greater percentage of our incomes for gasoline, and so we are very acutely aware of the escalating price of energy.

Today's hearing is going to focus on carbon sequestration for enhanced oil recovery. It is going to give us the chance to examine some of the important issues that face companies producing oil, and some of America's oldest oilfields, at the same time talking about the domestic challenges that we are going to face in producing the fuel that moves America and powers our economy. So we have kind of a two-pronged consideration.

Carbon capture and sequestration on a commercial scale is still an unproven technology. The process of separating and capturing carbon during the production of energy remains cost-prohibitive under current law.

As we are going to hear today, implementation of the capture program on a coal power plant may consume nearly 25 percent of the power generated by that plant. Those costs have to be calculated. The initial investment on that particular plant will in-

crease the cost by nearly 50 percent during the construction, from \$2 billion to \$3 billion. These costs for energy production will be passed along to the consumers who purchase electricity generated in these facilities.

Enhanced oil recovery is a technically challenged and costly process. I suspect I am the only Member of Congress who actually ran a business that was engaged in reclaiming old oilfields. My wife and I ran a fishing and rental tool company. We did repairs on these aging wells in Lee County, New Mexico, across the border in Texas, and now then we are watching with interest as CO_2 is being used to extend the life of those wells. But we are also very familiar with the technological challenges that come with that.

The process is not suited for all oilfields. You cannot go into just any oilfield and start injecting carbon dioxide. The process simply has to have the right formation to work, and it will not work across the spectrum of oilfields in America. It is important to note that enhanced oil recovery is no replacement for new oilfield development.

While the EOR can extend the life of a field by 10, 20, or even 30 years, America's oil producers need access to new developments and new reserves to ensure that America has the resources to keep our economy moving forward. We have the resources here in America, but many of them are locked up, like the Outer Continental Shelf, ANWR, or simply banned from development, like oil shale in Colorado and Utah.

This hearing will highlight that while EOR can help America keep producing oil, it does produce, it does need new oil, and it is not, the enhanced oil recovery is not a solution to our energy crisis.

There is concern that this hearing may be the start of a process that would move legislation banning the mining of CO_2 from natural sources. That would be very misguided. Since mined CO_2 is never released into the atmosphere, such a step would only increase costs for companies engaged in the EOR, while having no impact on reducing atmospheric CO_2 concentrations.

I would hope that going forward, we can give the companies engaged in the process the confidence that they are not going to see their investments disrupted by misguided and misdirected legislation. We have already seen that in close detail on the conversion of corn to ethanol; we have seen the tremendous pressure on our water resources, now greater acres than ever are being plowed up in our rain forests. And finally, the conversion of food to fuel is causing hunger throughout the world.

Finally, Mr. Chairman, while this hearing touches on the issue of domestic energy, it is not about actually producing new domestic energy. At a time when Americans are facing record energy costs, this committee has the responsibility to take steps to address how to increase domestic oil production and reduce costs.

I would ask you, Mr. Chairman, to hold a hearing next week, where we are working together. We invite witnesses and talk about the specific steps we could take to increase domestic energy production, reduce our dependence on foreign oil, reduce gasoline costs for our constituents, and more importantly, help America get our economy moving forward.

I hope you will consider my request. And I yield back, looking forward to the testimony that we hear from our witnesses today.

[The prepared statement of Mr. Pearce follows:]

Statement of The Honorable Steve Pearce, Ranking Member, Subcommittee on Energy and Mineral Resources

Mr. Chairman, thank you for holding this hearing today. This Committee is meeting at a time when Americans are facing record and rising gasoline costs. Yesterday, the national average for gasoline surpassed $4.05 a gallon, and is significantly higher in states like California and here in the District of Columbia.

Everyday Americans are paying record portions of their income in energy costs. This burden is carried by poor and working citizens, like my constituents in New Mexico, at 47th in per capita income, who pay America's highest percentage of their income for energy costs.

Today's hearing will focus on Carbon Sequestration for Enhanced Oil Recovery.

This hearing will give us a chance to examine some of the important issues face companies producing oil on some of America's oldest oil fields. At the same time, talking about the domestic challenges they face in producing the fuel that moves America and powers our economy.

CARBON CAPTURE

Carbon capture and sequestration on the commercial scale remains an unproven technology. The process of separating and capturing carbon during the production of energy remains cost prohibitive under current law. As we are going to hear today, implementation of a capture program on a coal power plant may consume nearly 25 percent of the power generated by that plant. The initial investment will increase the costs nearly 50%, from $2 Billion to $3 Billion, for the construction of the plant. These costs for energy production will be passed along to the consumers who purchase electricity generated in these facilities.

ENHANCED OIL RECOVERY (EOR)

Enhanced oil recovery is a technically challenging and costly process. I am probably one on the only Members of Congress who has personal experience working in these older oil fields. My wife and I operated a fishing business which worked to repair wells in older oil fields, like those using to EOR. Near my home in Lea County, New Mexico, and across the border in Texas, this process is being used to extend the life of some of America's oldest oil fields.

However, this process is not suited to all of America's oil fields and simply because the process works in Texas and New Mexico doesn't mean that it will work in every oil field in America. It is important to conduct EOR that you have the right underground formation.

AMERICAN RESOURCES

It is also important to note that Enhanced Oil Recovery is no replacement for new oil field development. While EOR can extend the life of a field by 10, 20, maybe 30 years, America's oil producers need access to new development and new reserves to ensure that America has the resources to keep our economy moving forward.

We have the resources here in America but many of them are locked up, like the OCS and ANWR or simply banned from development like the oil shale of Colorado and Utah. This hearing will highlight that while EOR can help America keep producing oil, it does need new oil, and is not a solution to our energy crisis.

LEGISLATION

There is concern that this hearing may be the start of a process to move legislation banning the mining of CO_2 from natural sources misguided. Since mined CO_2 is never released into the atmosphere such a step would only increase costs for companies engaged in EOR while having no impact on reducing atmospheric CO_2 concentrations. I would hope that going forward we could give the companies engaging in this process the confidence that they are not going to see their investments disrupted by misguided and misdirected legislation. We have seen this happen with the development of Ethanol, where we believed that we could grow our way to energy independence, instead we are facing water shortages, worldwide deforestation and growing hunger from rising food costs.

HEARING

Finally, Mr. Chairman while this hearing touches on the issue of domestic energy; it is not about actually producing new sources domestic energy. At a time when

Americans are facing record energy costs this committee has the responsibility to take steps to address how to increase domestic oil production and reduce costs.

I would ask you Mr. Chairman to work with me to hold a fair hearing next week where working together we invite witnesses and talk about the specific steps we could take to increase domestic energy production, reduce our dependence on foreign oil, reduce gasoline costs for our constituents, and more importantly help America get our economy moving forward.

Mr. COSTA. Thank you very much, gentleman from New Mexico. Always willing to consider any requests and good ideas. I do believe, in fact, that there are multiple management tools in our energy toolbox to deal with our issue. And certainly our oil and gas production domestically, in terms of ensuring that we are as effective as we possibly can, is one of the issues that I support.

We have increased application for permits to drill by 361 percent, beginning at the end of the Clinton Administration and throughout the Bush Administration. Today there are over 28,000 active application of permits to drill, and the energy companies that have bid on those application of permits to drill that have been approved through the Minerals Management Service are active on over 18,000, which means that there are over 10,000 that are currently not being utilized.

But I believe that we need to examine all efforts. I was in the Gulf of Mexico several months ago, and there is tremendous activity taking place out there, as we all know, and the recent bids that have taken place. We have had record bids at that, on when they become available, for those companies that are participating in them. And that really reflects, I think, in part the desire on energy companies in our country to maximize our efforts for both onshore, as well as offshore, opportunities for oil and gas.

And while I can tell you, because I know a little bit about my schedule next week, that we can't do that next week, it is a subject of something that I have been entertaining, because we do have an energy crisis in this country. I agree with you on that point. And it is not going to go away.

And nor do I believe that there are any silver bullets, whether it is corn or anything of the list of menus that people have that have good ideas, and they are good ideas. But there is no one sole source of solutions. It is, in my view, a combination of solutions that are involved, short-term and long-term efforts. And if we are going to be successful, it is going to have to be done in a bipartisan way, in my opinion.

So, to appropriately respond to your comments, and I hope I did, I think it is important that we get into the meat of this morning's hearing, which is part of this larger conversation.

Let me say for those of you, we have been told that the schedule is as follows: that we are going to have votes around 11:00. And so my desire is to have our first panel testify; have a round of questions to the first panel. I am not sure we are going to be able to do this, but I would like to then get to the second panel, and at least get the second panel to be able to all make their opening statements before we have to go and vote. I don't know how many votes we are going to have. Four votes.

Four votes usually, for those of you who aren't familiar with our drill across the street, usually involves about 40 minutes, or 30 to

40 minutes. So some time after 11:00 there will be a 30- to 40-minute break when we are forced, not forced, but when we are required to fulfill our other obligations, which is to vote on behalf of our constituencies.

So with that understood, we will begin with our first panel.

Mr. Timothy Spisak. Did I pronounce it right?

Mr. SPISAK. Spisak, yes.

Mr. COSTA. Spisak, is the Chief of Fluid Minerals Division of the Bureau of Land Management. And Mr. Scott Klara is also with us today, and we are looking forward to your testimony.

I think you understand the drill. You have those lights in front of you. It is five-minute timing. The green light means that you have four minutes, and then when the yellow light goes on you are on your last minute. And we do try to stay within the timeframe of the five minutes allowed for your oral testimony. Obviously, if you have more lengthy testimony, that is submitted for the record.

So let us begin, Mr. Spisak, with your testimony, please.

STATEMENT OF TIMOTHY SPISAK, CHIEF, FLUID MINERALS DIVISION, BUREAU OF LAND MANAGEMENT

Mr. SPISAK. Mr. Chairman, members of the Subcommittee, thank you for the opportunity to be here today to discuss enhanced oil recovery using carbon dioxide on public land.

As you mentioned, my name is Tim Spisak, Fluid Minerals Division Chief for the Bureau of Land Management, and I oversee the BLM's oil and gas program.

My testimony today will address ongoing enhanced oil recovery efforts and future plans for large-scale carbon sequestration projects on public lands. Enhanced oil recovery, or EOR, is a process used to recover more oil than can be obtained by natural pressure, through the injection of fuel or gas, such as CO_2, into an oil reservoir to force more to the surface.

CO_2 is a leasable commodity for which BLM collects royalties, and can be a byproduct of oil and gas production on public lands. The decision to undertake CO_2 EOR is largely that of industry, and is generally guided by financial considerations which balance infrastructure needs and the cost of CO_2 against the anticipated return to determine whether the investment is justified.

Within the BLM's regulated authority to administer oil and gas leases, EOR is generally approved as part of a secondary unit agreement and sundry notices, in order to ensure that the company is moving forward in accordance with regulation and policy.

Geological storage of carbon dioxide involves injection of CO_2 into a subsurface rock unit, and displacement of the fluid or formation water that occupied the pore space. This principle operates in all types of potential geological storage formations, such as oil and gas fields, coalbeds, and deep saline water-bearing formations.

Most of the potential CO_2 storage capacity in the U.S. is in these deep saline formations. The BLM anticipates taking a leading role, working with other agencies, to evaluate and develop where appropriate long-term carbon sequestration efforts.

The BLM is currently working with partners on demonstration projects, including a deep saline sequestration project in Utah, and an enhanced coalbed methane project in Mexico.

The BLM existing administrative and regulatory structure will help facilitate future carbon sequestration projects, and potentially leasing. We expect these continuing efforts to lead to a robust, coordinated regulatory framework.

The BLM's experience in administering a large-scale mineral leasing program, issuing rights-of-way on public land, and other programmatic and land-management expertise will facilitate this effort. As called for by the Energy Independence and Security Act, Section 714, the BLM is working in coordination with USGS, DOE, EPA, and others, to complete a report to Congress by December 2008, outlining a recommended framework for geologic sequestration on public lands.

As long-term sequestration efforts advance, a number of issues will need to be addressed. These issues include the economics of geologic sequestration of man-made CO_2, the feasibility and logistics of long-term geologic containment of CO_2, the ownership of formation pore space on split-estate lands, the liability and safety issues related to potential release of CO_2 stored underground, or potential saltwater intrusion into freshwater aquifers, and the degree of public acceptance of the construction and operation of nearby CO_2 sequestration facilities.

As the nation's largest Federal land manager, the BLM recognizes its responsibilities to the country, and the opportunity to play a key role in EOR and carbon capture and sequestration. I look forward to providing you the results of our efforts in December, and would be happy to answer any of your questions.

[The prepared statement of Mr. Spisak follows:]

Statement of Tim Spisak, Division Chief, Fluid Minerals, Bureau of Land Management, U.S. Department of the Interior

Introduction

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to be here today to discuss enhanced oil recovery using carbon dioxide on public lands. I am Tim Spisak, Division Chief for Fluid Minerals for the Bureau of Land Management (BLM), and I oversee the BLM's Oil and Gas program. My testimony today will address on-going enhanced oil recovery efforts and progress to date and future plans for large-scale carbon sequestration projects on public lands.

BLM-managed public lands and minerals continue to play an important role in meeting the Nation's energy needs. Increases in energy prices are affecting the Nation as a whole. The BLM is looking to continue to facilitate the development of oil and gas resources on the public lands in addition to providing for alternative and renewable forms of energy in an environmentally-sound way.

As the Nation's largest land manager, the BLM is entrusted with the multiple-use management of 258 million acres of land, and administers 700 million acres of sub-surface mineral estate of which the surface owners are Federal agencies, states, or private entities. Of the 1.2 billion acres inventoried by the U.S. Geological Survey (USGS) in its National Oil and Gas Assessment, 279 million acres are under Federal management. The recently released Energy Policy and Conservation Act (EPCA) Phase III Report found that these resources translate into 30.5 billion barrels of undeveloped oil and 5.3 billion barrels of proven reserves. These areas currently under lease are the most likely for enhanced oil recovery in the short term.

In 2007, nearly 3,500 new oil and gas leases were issued and approximately 500 of the more than 5,340 wells spud on over 4.6 million acres of leased Federal land were for oil production. We are diligent in executing our responsibilities to make these resources available in an environmentally-sound manner. Within the framework of a transparent public process, we carefully consider any potential effects to habitat, groundwater, air and other resources; mitigate impacts through best management practices, stipulations and conditions of approval; and balance development with other uses across the landscape. It is our role, with the appropriate environmental protections in place, to provide the tools needed to allow oil production from

leased resources, to facilitate the pioneering of new technology, and to ensure a fair return to the American taxpayer from the development of resources from public lands.

Escalating oil prices affect not only interest in domestic production, but also the viability of industry to pursue unconventional and renewable fuels through advanced technologies and processes. New technologies may allow industry to effectively recover resources that were once determined to be too expensive to pursue. Continuing to support and advance these efforts, in part, is essential to addressing the energy issues we now face.

Enhanced Oil Recovery

Enhanced oil recovery (EOR) is a process used to recover more oil than can be obtained by natural pressure, through the injection of fluid or gas into an oil reservoir to force more oil to the surface. Carbon dioxide injection is one type of EOR. This process is often undertaken in the later stages of an oil and gas operation, but may be done at an earlier stage. The decision to undertake enhanced oil recovery is largely that of industry, and is generally guided by financial considerations. Industry balances infrastructure and the cost of carbon dioxide (or other medium) against the anticipated return to determine whether the investment is justified. Within the BLM's regulatory authority to administer oil and gas leases, EOR is generally incorporated into a "sundry notice" in order to ensure that the company is moving forward in accordance with the appropriate rules, regulations, and policies. An example of currently operating carbon dioxide EOR on Federal lands is the Salt Creek Field, a relatively shallow field in Wyoming that was developed in the early 1900's. In more recent times, it has become cost effective for industry to re-develop this field using modern technology and extract resources left behind after earlier efforts. Following substantial reconstruction of existing infrastructure, carbon dioxide injection EOR has been employed, effectively doubling production. In the process, 150 million cubic feet of carbon dioxide is injected per day that would otherwise have been vented to the atmosphere.

In addition to its use in enhancing oil recovery, carbon dioxide is a leasable commodity under the Mineral Leasing Act of 1920. The BLM currently collects revenues in the form of royalties derived from the sale of carbon dioxide produced in connection with oil and gas production on public lands. In 2007, the sale of carbon dioxide generated over $23 million in royalty revenue in the states of Colorado, New Mexico, and Wyoming.

EOR's use of carbon injection will continue to yield valuable data and information that facilitates future efforts to effectively capture and sequester carbon dioxide in geologic formations found on public lands. A critical issue for evaluation of storage capacity is the integrity and effectiveness of these formations for sealing carbon dioxide underground, thereby preventing its release into the atmosphere. Current EOR efforts will enhance our understanding of these types of critical scientific and geologic issues. We expect that new information on this technology and the issues it presents will continue to be generated from activities on the public lands that we manage. As such, we anticipate the need for BLM to play an important role in collaborating with other Federal agencies, states, the private sector, and the public as we move forward in addressing legal and policy issues that arise during development.

Carbon Capture and Sequestration (CCS)

The current atmospheric carbon dioxide concentration is approximately 380 parts per million volume and rising at a rate of approximately 2 parts per million volume annually, according to the most recent information from the Intergovernmental Panel on Climate Change (IPCC). The 2005 IPCC Special Report on Carbon Dioxide Capture and Storage concluded that in emissions reductions scenarios striving to stabilize global atmospheric carbon dioxide concentrations at targets ranging from 450 to 750 parts per million volume, the global storage capacity of geologic formations may be able to accommodate most of the captured carbon dioxide. However, it is not known how much of this carbon dioxide storage capacity would be economically feasible (assuming some price on carbon). Also, geologic storage capacity may vary widely on a regional and National scale. A more refined understanding of geologic storage capacity is needed to address these knowledge gaps.

The challenges of addressing carbon dioxide accumulation in the atmosphere are significant. Fossil fuel usage, a major source of carbon dioxide emissions to the atmosphere, will continue for the foreseeable future in both industrialized and developing nations. Therefore, a variety of strategies are being investigated to reduce emissions and remove carbon dioxide from the atmosphere. Such strategies include the facilitated sequestration of carbon for the capture and storage of carbon dioxide

through terrestrial sequestration using soils and trees, or by injection into geologic formations.

Geological storage of carbon dioxide in porous and permeable rocks involves injection of carbon dioxide into a subsurface rock unit and displacement of the fluid or formation water that initially occupied the pore space. This principle operates in all types of potential geological storage formations such as oil and gas fields, deep saline water-bearing formations, or coal beds. Most of the potential carbon dioxide storage capacity in the U.S. is in deep saline formations.

The BLM anticipates taking a leadership role, in collaboration with other agencies, in evaluating and developing, where appropriate, long-term carbon sequestration efforts. The BLM's existing administrative and regulatory framework will help facilitate future carbon sequestration demonstration projects and potentially, leasing, and ultimately inform a robust, coordinated regulatory regime. In addition to experience in administering a large-scale mineral leasing program, we have the realty expertise and an existing framework for issuing rights-of-way on public land that could serve future needs for carbon dioxide pipelines across public lands. Other programmatic and land management expertise, such as the BLM's experience in evaluation of potential environmental impacts of projects, will facilitate this effort. Other agencies, such as USGS, DOE, and EPA will also play an important role in recommending geologic criteria that could be incorporated into a set of "best practices" for geologic site selection. The BLM looks forward to working closely with the USGS, DOE, EPA, the National laboratories, other Federal agencies, academia, industry and the public to develop geologic and technical criteria that could be used in future site selection.

At this early stage in the development of carbon dioxide storage technologies, especially in the absence of large-scale demonstration projects of more than 1 million tons of carbon dioxide per year, many unknown factors may impact the development of best practices. We look forward to working together to resolve outstanding legal and policy questions as we continue to learn more about the technologies and geologic information necessary in moving forward with a carbon sequestration program. We understand that the Environmental Protection Agency (EPA) plans to propose regulations for issuing Safe Drinking Water Act permits for geologic sequestration of carbon dioxide. BLM will provide input as appropriate in the rulemaking process.

Current CCS Demonstration Projects—The BLM is working with the Department of Energy (DOE) on regional partnerships that promote CCS demonstration projects. In promoting CCS efforts on public lands, the BLM is currently active in two demonstration projects: a deep saline sequestration project in Farnham Dome, Utah, and an enhanced coalbed methane project in San Juan Basin, New Mexico.

- The Farnham Dome project involves the reinjection and storage over a four year period of carbon dioxide produced on state and Federal lands with site monitoring for an additional 5 years. As a cost incentive for the demonstration project, the BLM has agreed to defer royalty payments on carbon dioxide produced from the Federal mineral estate (90 percent of the project area) until after the demonstration project when the carbon dioxide may be produced for commercial gain.
- The San Juan Basin project will demonstrate the feasibility of carbon dioxide coalbed sequestration while determining the potential for enhanced recovery of coalbed methane by injecting 75,000 tons of carbon dioxide into the formation over a one-year period.

We look forward to evaluating the results of these projects and to using these results to explore additional demonstration projects on public lands. If appropriate, we will begin looking at the costs and benefits of moving forward to develop a program for public lands. As the largest Federal land manager, the BLM will continue to support these demonstration projects, as well as other demonstration project opportunities that may be identified involving resources managed by the BLM.

Energy Independence and Security Act

The BLM is currently implementing the carbon capture and storage provisions of the Energy Independence and Security Act (EISA) [Public Law 110-140]. Section 713 of EISA directs the BLM to maintain records on, and an inventory of, the quantity of carbon dioxide stored within Federal mineral leaseholds. The BLM is reviewing its current data collection structures and methods, including commercially available data, and will determine how this new data collection requirement can be incorporated into existing systems. The BLM is coordinating with the Minerals Management Service on changes that may be required to the Oil and Gas Operations Report that is used to collect production and injection data on Federal mineral estate.

Section 714 of the EISA directs the Secretary of the Interior to submit a report to Congress by December 2008 containing a recommended framework for geological sequestration on public lands. In coordination with the Environmental Protection Agency, the Department of Energy, USGS, and other appropriate agencies, the BLM is examining criteria for identifying candidate geological sequestration sites in several specific types of geological settings. Additionally, the BLM will consider the EPA proposed regulations for carbon capture and sequestration when available to ensure that all of the BLM's recommendations are in compliance with the Safe Drinking Water Act and regulations under that Act. The BLM will be considering a regulatory framework for the leasing of public lands for the long-term geological sequestration of carbon dioxide, while providing for public review and protecting the quality of natural and cultural resources.

Future Efforts

As the BLM advances long-term carbon sequestration efforts, several issues need to be addressed. Federal leasehold or Federal mineral estate liability issues related to the release of carbon dioxide stored underground will need to be studied and evaluated. Relevant experiences from enhanced oil recovery using carbon dioxide on public lands will assist us in examining this issue. In addition to scientific and geologic issues, legal and regulatory issues remain, specific to carbon dioxide sequestration on land in cases in which title to mineral resources is held by the United States, but title to the surface estate is not.

In preparing our report to Congress under EISA, the BLM will examine existing statutes, regulations, proposed regulations, and case law, and recommend whether additional legislation may be necessary to ensure that public land management and leasing laws are sufficient to accommodate the long-term geological sequestration of carbon dioxide on public lands.

In the meantime, the BLM plans to participate and expand its involvement in carbon dioxide research, development and demonstration projects. We will also continue to permit enhanced oil recovery operations on public land; analyze the data we are beginning to collect under Section 713 of EISA; examine the adequacy of existing regulations and proposed regulations; and move forward on other recommendations that will be developed over the next six months.

Conclusion

Addressing the challenges of reducing atmospheric carbon dioxide and understanding the effects of global climate change are complex issues with many interrelated components. Geologic sequestration of carbon dioxide is one of several mechanisms being investigated by the scientific community. While promising, a number of unknowns remain.

- Existing demonstration projects have studied injection of carbon dioxide of geologic origin rather than atmospheric carbon dioxide. The economics of capturing and sequestering carbon dioxide from other sources are not well understood.
- Significant technological, scientific, and logistical challenges remain in geologic carbon sequestration, such as the ability to evaluate formations for containment capabilities over long periods of time, measured in hundreds or thousands of years. However, large scale demonstration projects such as those described earlier in my testimony will begin to address these challenges.
- Complex questions on access, compensation, and ownership of formation pore space on split-estate lands have not yet been resolved.
- Abandoned wells in proximity to injection sites often are not able to contain pressure increases associated with carbon dioxide injection, and can require substantial re-engineering.
- Liability and safety questions in the event of carbon dioxide leakage or salt water intrusion into fresh water aquifers are unresolved, although research jointly sponsored by EPA and DOE is underway to assess these issues.
- The degree of public acceptance of the construction and operation of nearby carbon dioxide sequestration facilities is unknown.

The assessment activities required by the BLM in EISA should ultimately increase the information base upon which decision makers will rely as they deal with these issues. In addition to addressing the challenges presented by carbon dioxide, this commodity presents certain opportunities for future knowledge and use. The BLM stands ready to assist Congress as it examines these challenges and opportunities.

The BLM will continue to support our Nation's energy needs and facilitate the pioneering of new technology and processes. As the Nation's largest Federal land manager, the BLM recognizes its responsibilities to the country and the opportunity to play a key role in enhanced oil recovery and carbon capture and sequestration.

I look forward to providing you with the results of our efforts this December. I would be happy to answer your questions.

Mr. COSTA. Thank you very much, Mr. Spisak. And you stayed within the five minutes. We usually give gold stars for that.

Our next witness, and I misspoke earlier, is Mr. Scott Klara with an L, not Kara, and I apologize for my misspeak, Director of the Strategic Center for Coal with the National Energy Technology Laboratory, which is a part of the Department of Energy.

So Mr. Klara, please begin your testimony.

STATEMENT OF SCOTT KLARA, DIRECTOR, STRATEGIC CENTER FOR COAL, NATIONAL ENERGY TECHNOLOGY LABORATORY

Mr. KLARA. Thank you, Mr. Chairman and members of the Subcommittee. It is a pleasure to be here.

I appreciate the opportunity to provide testimony on the U.S. Department of Energy's research efforts in enhanced oil recovery using carbon dioxide; and in particular, its relevance to carbon sequestration.

Throughout my brief remarks, I will refer to carbon dioxide as CO_2, and enhanced oil recovery as EOR.

Mr. COSTA. That works for us.

Mr. KLARA. Although much of the nation's original onshore oil resource reserves have been produced, the Nation is still home to a large resource of oil. Large volumes of oil remain stranded in the reservoir. In fact, as much as 70 percent of the oil in the reservoir remains stranded due to technical and economic hurdles associated with primary extraction methods.

Extraction of a significant fraction of the stranded oil is possible through the advances of technology related to CO_2 EOR.

Fossil fuel combustion and fossil fuel power plants in particular are a major source of CO_2 emissions of potent greenhouse gas. In fact, fossil fuel power generation accounts for more than one-third of the U.S. anthropogenic greenhouse gas emissions, and CO_2 in particular accounts for 80 percent of all U.S. greenhouse gas emissions.

There is some good news. And that good news is that technologies are under development that can potentially provide significant reductions in CO_2 emissions from fossil-fueled power plants.

Now, what if we were to try to tie these two challenges together: Increasing domestic oil recovery and reducing CO_2 emissions from fossil-fueled power plants? This coupling becomes possible by the topic of this hearing, which is linking the capture of carbon CO_2 from sources like power plants, and using this CO_2 for EOR.

The Department has recognized the importance of CO_2 EOR for more than 40 years. Since the 1970s, DOE-funded projects have been developing concepts to improve the effectiveness and applicability of CO_2 EOR.

Current EOR research has begun to focus now on the carbon storage aspect of the process. In parallel with these developments, the Department also conducts research on future energy conversion technologies that will minimize CO_2 emissions by developing cost-effective approaches for efficiently capturing CO_2 from fossil-fueled

power plants, and safely and permanently storing these in underground formations.

Several key areas that make up this research program are subelements like gasification, advanced turbines, fuel cells, carbon capture, and sequestration. My written testimony has more detail about those program areas.

I would like to now briefly elaborate a bit more on one key research program, the carbon sequestration program.

Carbon sequestration developments are addressing the key challenges that confront the widescale deployment of capture-and-storage technology through research on several areas: Cost-effective capture technologies, monitoring, mitigation and verification technologies to ensure permanent storage, permitting issues, liability issues, public outreach, and infrastructure needs.

Relative to EOR, the program is focusing on technologies for monitoring, mitigation, and verification that will validate permanent CO_2 storage and EOR applications, and provide the necessary tools and best-practice protocols for using EOR as a carbon storage option. The Department's sequestration program was recently recognized by the EIA greenhouse gas group as the world's most ambitious program dedicated to the advancement of carbon-capture and storage technologies.

My written testimony provides many facts, data, and references that highlight the potential of CO_2 EOR and its relationship to CO_2 storage. CO_2 EOR represents an early opportunity for helping to realize carbon-capture and sequestration technologies. Developing the technology base to support a widespread expansion of CO_2 EOR could substantially increase existing United States oil reserves and oil production.

The Department's developmental efforts are providing the elements necessary to help enable this expansion by advancing carbon-capture and storage technologies to increase the supply of carbon dioxide, and optimizing EOR technologies for carbon sequestration co-benefits.

This completes my statement, and I look forward to additional discussion. Thank you.

[The prepared statement of Mr. Klara follows:]

Statement of Scott M. Klara, National Energy Technology Laboratory, U.S. Department of Energy

Thank you, Mr. Chairman and members of the Subcommittee. I appreciate this opportunity to provide testimony on the U.S. Department of Energy's (DOE's) research efforts in enhanced oil recovery (EOR) using carbon dioxide (CO_2) and its relevance to carbon sequestration.

Introduction

The economic prosperity of the United States over the past century has been built upon an abundance of fossil fuels in North America. The United States' fossil fuel resources represent a tremendous national asset. Making full use of this domestic asset in a responsible manner enables the country to fulfill its energy requirements, minimize detrimental environmental impacts, and positively contribute to national security.

The Nation is home to a large resource of oil. Although much of the Nation's original onshore petroleum reserves have been produced, large volumes of crude oil remain stranded in place after current production operations are completed because their extraction using current technology is both technically difficult and uneconomic. As much as 70% of the oil in a given reservoir remains stranded in place after current production operations are completed due to technological and economic

hurdles. The total volume of this stranded oil[1] is estimated by Advanced Resources International (ARI), of Washington, DC, to exceed 390 billion barrels, though DOE and the U.S. Geological Survey (USGS) have not yet validated the ARI estimates. Of this total, ARI estimates that roughly 200 billion barrels are relatively accessible at depths to 5,000 feet below the surface. Extraction can be aided technically and made more economic through the use of CO_2 for EOR. To put these numbers in context, according to the Energy Information Administration (EIA), we have produced about 195 billion barrels of our petroleum resources over the past 120 years and currently have proven reserves[2] of roughly 21 billion barrels. Proven reserves are those quantities of petroleum, which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under defined economic conditions, operating methods, and government regulations. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate. Stranded oil is not currently included in proven reserves. Stranded oil is a resource that could add substantially to reserves when technology becomes available and economic conditions allow. It is equal to the total reserves in place, minus the proven reserves.

There is also scientific consensus that increased levels of greenhouse gases in the atmosphere, primarily CO_2, methane, nitrous oxide, and chlorofluorocarbons, are linked to climate change. Globally, about 75-80% of total greenhouse gas emissions are CO_2. In this connection, fossil fuel combustion, in general, and fossil-fuel power plants, in particular, have been identified as a major source of anthropogenic greenhouse gas emissions, particularly CO_2, into the atmosphere. Slowing the growth of anthropogenic greenhouse gas emissions has become an important concern.

Both of these challenges—extending the supply of domestic fuels (primarily oil) and reducing emissions of CO_2 from fossil-fueled power plants (primarily those fired with coal)—can be addressed simultaneously through the use of captured CO_2 for achieving EOR. Currently, most EOR projects rely on the availability of cheap sources of naturally occurring CO_2. If research into reducing the cost of CO_2 capture from power plants proves successful, anthropogenic sources of CO_2 may become readily available for EOR projects. The Intergovernmental Panel on Climate Change has estimated a worldwide technical capacity for CO_2 storage in EOR applications at 61 to 123 billion tonnes of CO_2. Estimates by ARI, which DOE has not yet fully evaluated, have shown that the technical limit for CO_2 storage associated with EOR is 20 billion tons. Of that quantity, ARI estimates up to 12 billion tons could be economically stored, if EOR technology continues to advance and the cost of carbon capture technology is significantly reduced. If these potentials can begin to be realized, incremental oil produced via EOR using CO_2 flooding could help offset the costs of CO_2 capture, and the prospect of relatively low-cost supplies of captured CO_2 in widespread areas of the country could, in turn, provide the impetus for a national re-evaluation of the EOR potential in many mature fields. The proximity of sources of captured CO_2 to oil reserves amenable to EOR is an important consideration, because transportation of CO_2 over long distances is expensive and can affect the economics of EOR. The use of EOR for carbon sequestration will also involve permitting issues, liability issues, monitoring and verification technologies to ensure permanent storage, and public outreach.

In summary, while conventional EOR is a commercial process, CO_2 capture from coal power systems is not yet commercial at the large scale required for deployment in power plants. Continued evolution of EOR and transformational advances in development and deployment of CO_2 capture from coal power could help realize this synergy between the coal/power industry and the oil industry.

Technology Developments

The Department has recognized the importance of CO_2 EOR for more than forty years. As early as the 1970s, DOE-funded projects were assessing the fluid properties of CO_2 to establish its applicability in EOR. A special focus was given to developing correlations that helped the oil industry utilize these properties to improve EOR performance in commercial projects. Technological advances included the use of horizontal wells for improved reservoir contact, four-dimensional seismic to monitor the behavior of CO_2 floods, automated field-monitoring systems for detecting problems, and the injection of increasingly larger volumes of CO_2 to increase recov-

[1] Assessing Technical and Economic Recovery of Oil Resources in Residual Oil Zones, ARI, February 2006, www.adv-res.com/pdf/ROZ__Phase__II__Document.pdf.

[2] U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 2006 Annual Report, DOE/EIA-0216(2007), November 2007, www.eia.doe.gov/oil__gas/natural__gas/data__publications/crude__oil__natural__gas__reserves/cr.html.

ery rates. This DOE-funded research has helped to significantly advance industrial EOR operations, most of which currently use CO_2 from natural reservoirs, but the research focus is now on the carbon sequestration aspect of EOR, a developing application, rather than the mature oil production side of EOR.

Coupled with these advances in CO_2 EOR, the Office of Fossil Energy's Clean Coal Research & Development (R&D) Program provides for the development of new cost- and environmentally-effective approaches to coal use. The major focus of the program is developing future plant configurations that minimize CO_2 emissions by developing cost-effective approaches for efficiently capturing CO_2 from coal-fired plants, and safely and permanently sequestering the captured CO_2 in underground reservoirs. The key technology areas that make up the Clean Coal R&D Program are discussed in the following paragraphs.

Gasification is a pathway to convert coal or other carbon-containing feedstocks into synthesis gas. This synthesis gas, in turn, can be used as a fuel to generate electricity or steam, or as a basic raw material to produce hydrogen, high-value chemicals, and liquid transportation fuels. The Advanced Integrated Gasification Combined Cycle Program is developing advanced gasification technologies to meet the most stringent environmental regulations and facilitate the efficient capture of CO_2 for subsequent sequestration. Gasification plants are very amenable to CO_2 capture because they can be designed to produce a high-pressure stream of CO_2 that is easier to capture, compared to conventional power plant technologies. Advances in the current state-of-the-art, as well as the development of novel approaches, could provide the technical pathways enabling gasification to meet the demands of future energy markets, while minimizing greenhouse gas emissions.

The Advanced Turbine Program consists of a portfolio of laboratory and field R&D focused on performance-improvement technologies with great potential for increasing efficiency and reducing emissions and costs in coal-based applications. The Program focuses on the combustion of pure hydrogen fuels in large-scale turbines greater than 100-megawatt size range, and it has also worked on the development of less costly approaches for compressing large volumes of CO_2. Since advanced turbines will be fuel-flexible, capable of operating on hydrogen or syngas, they will make possible electric power generation in gasification applications configured to capture CO_2.

Fuel Cells hold great potential to provide substantial improvements to the efficiency and emission reductions of future power plants. Fuel cell emissions per unit of electric power produced are well below current and proposed environmental limits for commercial power sources. Their modular nature permits use in central or distributed generation with equal ease. Rapid response to emergent energy needs is enhanced by the modularity and fuel flexibility of fuel cells. The ultimate goal of the program is the development of low-cost, megawatt-scale fuel cell power systems that will produce affordable, efficient, and clean electric power both as stand-alone sources, or when they are incorporated into integrated coal gasification combined-cycle systems equipped with CO_2 capture and sequestration.

Carbon sequestration developments are addressing the key challenges that confront the wide-scale deployment of capture and storage technologies through research on cost-effective capture technologies; monitoring, mitigation, and verification technologies to ensure permanent storage; permitting issues; liability issues; public outreach; and infrastructure needs. For example, relative to capture costs, today's commercially available capture and storage technologies will add around 80% to the cost of electricity for a new pulverized coal plant, and around 35% to the cost of electricity for a new advanced gasification-based plant. [3] The Carbon Sequestration Program is aggressively pursuing developments to reduce these costs to less than a 10% increase in the cost of electricity for new gasification-based energy plants, and is developing a goal for pulverized-coal energy plants. Relative to EOR, the program is focusing on technologies for monitoring, mitigation, and verification that will validate permanent CO_2 storage in these applications, and provide the necessary best practices protocols for using EOR as a carbon storage option.

EOR and Sequestration Potential

Many EOR processes incorporating thermal, chemical, microbial, and a variety of miscible gas-injection methods have been employed in the United States. Among these, CO_2EOR is likely the most promising technology. Because CO_2 is miscible with crude oil under certain conditions, it can be injected into previously drained oil reservoirs and used to sweep a portion of the remaining oil from the reservoir,

[3] 3 Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity, U.S. Department of Energy/National Energy Technology Laboratory, DOE/NETL-2007/1281, Final Report, May 2007.

thereby helping to overcome the physical forces that trap the residual oil. While not all of the relatively easily accessible stranded oil is susceptible for recovery by CO_2-EOR, a large proportion could be recovered if a source of low-cost CO_2 and advanced CO_2-EOR technologies are developed and deployed.

A series of CO_2-EOR assessments conducted by ARI have projected that, if current high oil prices are sustained over the long-term, if low-cost captured CO_2 from power plants is available, and if there continue to be improvements in CO_2-EOR technology, 89 billion barrels of incremental oil—more than four times the current U.S. proved reserves—may be economic to produce. It was also noted in this study that widespread use of improved CO_2-EOR technologies and modified processes that emphasize using increased volumes of CO_2 in each reservoir could result in three times as much CO_2 being used, and five times more oil being recovered. These changes could result in significant recovery of this incremental oil. Since oil companies take many factors and risks into consideration when determining which investments to make, it is unlikely that all of the additional 89 billion barrels of domestic oil would be produced, due to the complexities of corporate investment decisions. DOE has not yet fully evaluated these projections and their relevance to DOE activities.

ARI estimates that within just the large fields in North Dakota's portion of the Williston Basin, as much as 390 million barrels of incremental oil could have a cost of production less than the current price of oil, though DOE and USGS have not yet verified these estimates. In addition, the feasibility of converting the large unconventional in-place resource within the Bakken Shale of North Dakota into economic reserves has been examined by USGS. Their recent study estimates that nearly 4 billion barrels of (undiscovered) oil are technically recoverable from the Bakken Shale formation [4]. Additionally, a 2006 study by the North Dakota Geological Survey, which DOE and USGS have not yet verified, suggested that by using next generation CO_2-EOR technology, as much as 400 billion barrels, or more, of oil resource may be in-place [5]. If injection of CO_2 into this fractured shale could mobilize even a minor portion of this larger estimate, the Williston Basin's contribution to the Nation's oil supply would be significantly expanded.

In addition, while the main focus of CO_2-EOR is on maximizing the amount of oil produced rather than the amount of CO_2 injected, its sequestration potential is still significant, though much less than the sequestration potential of saline formations in the United States. Estimates by ARI, which DOE is evaluating, have shown that the technical limit for CO_2 storage associated with EOR is 20 billion tonnes. Of that quantity, up to 12 billion tonnes could be economically stored if EOR technology continues to advance, and assuming that the cost of CO_2 is less than \$30-\$38/ton delivered, which would require significant advances in carbon capture technology. To put this into context, total anthropogenic emissions of CO_2 in the United States is around 6 billion tonnes per year, with around 2 billion tonnes per year of this CO_2 from coal-fired power plants.

Conclusion

CO_2-EOR represents an early major opportunity for helping to realize carbon capture and sequestration technologies. The use of CO_2-EOR projects could help power generation companies to take advantage of the oil industry's expertise with CO_2 handling and injection, and help accelerate the implementation of other underground CO_2 sequestration options in coalbeds, depleted oil/gas reservoirs, and deep saline formations. Developing the technology base needed to support a widespread expansion of CO_2-EOR could substantially increase existing United States' oil reserves and production. The Department's development efforts are providing the elements needed to help enable this expansion by advancing capture technologies to increase the supply of CO_2 and optimize EOR technologies for carbon sequestration co-benefits.

Mr. Chairman, and members of the Subcommittee, this completes my statement. I would be happy to take any questions you may have.

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[4] USGS, Assessment of Undiscovered Oil Resources in the Devonian-Mississippian Bakken Formation, Williston Basin Province, Montana and North Dakota, April 2008.

[5] Bakken Formation Reserve Estimates, Julie LeFever and Lynn Helms, North Dakota Geological Survey, 2006.

Response to questions submitted for the record by Scott M. Klara, National Energy Technology Laboratory, U.S. Department of Energy

1. **Mr. Klara, last year the Department of Energy released a study on America's Unconventional Fuels that recommended an aggressive program for productively using industrial carbon dioxide emissions for EOR. What would such a program entail, how does it fit into the Department's existing carbon dioxide capture program, and what would it cost?**

Response 1. The Department of Energy's (DOE) program for geologic storage of carbon dioxide focuses on saline formations because they have by far the largest capacity for carbon storage of any type of domestic geologic formation. While EOR represents a good low-hanging fruit for carbon sequestration, only saline formations have capacity on the scale that would be needed to sequester the carbon emissions from domestic coal power generation. Base EOR technology—using carbon dioxide to increase oil production—is commercially available and widely deployed, and the industry has both the financial incentives and resources to advance the technology on its own. The DOE program is focusing on EOR sequestration technologies where the private sector lacks incentive: monitoring, mitigation, and verification that will validate permanent CO_2 storage in these applications, and best practices protocols for using EOR as a carbon storage option. While EOR-related CO_2 research is not a specific line item within DOE's Sequestration Program, based on the 2009 President's Budget Request it is estimated that approximately $7 to $9 million will be provided for EOR-related activities within the Sequestration Program, primarily through field testing activities. In addition, many of the technologies DOE is developing for geologic carbon storage in saline and other non-EOR formations are also applicable to EOR. The 2009 President's Budget Request provides $149 million for the Sequestration Program of which approximately $134 million is for geologic storage and $15 million is for capture R&D activities.

2. **Mr. Klara, what has the Department's budget for Enhanced Oil Recovery research been for each of the past 5 years?**

Response 2.

Dollars in Millions

Fiscal Year	2003*	2004*	2005*	2006*	2007	2008
Adj. Budget Auth.	$5.133	$6.915	$5.839	$6.435	$0	$3.765

*Includes broad-based Reservoir Efficiency Processes laboratory studies in addition to CO_2-EOR field tests. In addition, many of the technologies DOE is developing for geologic carbon storage in saline and other non-EOR formations are also applicable to EOR.

3. **Mr. Klara, what type of research is the Department into, Enhanced Gas Recovery or Enhanced Coal Bed Methane recovery?**

Response 3. DOE is currently pursuing unconventional gas technology research and development (R&D) with mandatory funds provided by the Energy Policy Act of 2005, Subtitle J, Section 999, which NETL manages and implements. The 2009 Budget proposes to repeal the mandatory oil and gas R&D program because the industry has the financial incentives and resources to develop new ways to extract oil and gas from the ground more cheaply and safely. Coalbed methane recovery is one small aspect of that program; however, nearly all current work in Section 999 is related to technologies focused on enhancing recovery of natural gas from fractured shales.

4. **Mr. Klara, has the Department of Energy carried out the Enhanced Oil Recovery demonstration program mandated by Section 354 of the Energy Policy Act of 2005? Could you provide us with an update on the progress of that program?**

Response 4. The DOE carbon sequestration program's EOR activities focus on EOR sequestration technologies where the private sector lacks incentive: monitoring, mitigation, and verification that will validate permanent CO_2 storage in these applications, and best practices protocols for using EOR as a carbon storage option. Consistent with Section 354(c)(2)(B), the Department issued a solicitation on February 1, 2006, for Enhanced Oil Recovery (EOR) field tests. The solicitation closed on May 5, 2006. Project selection was made on July 21, 2006, and a news release announcing the selection was published on the National Energy Technology

Laboratory's website on September 6, 2006. One award was made to the University of Alabama.

Status of the project initiated under the program: Following the completion of a detailed reservoir characterization effort, the University of Alabama initiated studies to establish the feasibility of using carbon dioxide (CO_2) for EOR in the heterogeneous Citronelle field in Alabama. That feasibility has been confirmed and pilot flood design efforts are almost concluded. Concurrently with the determination of feasibility, the University's industry partner, Denbury Resources, initiated field work to refurbish wellbores and facilities in preparation for a 5-spot pilot CO_2 flood. The pilot design is scheduled for completion in July 2008 and will be submitted for NETL review prior to the initiation of field CO_2-EOR pilot operations. The pilot is anticipated to start around November 2008. If the pilot is successful, Denbury Resources plans to extend their existing CO_2 flooding operations near Jackson Dome, Mississippi, to the Citronelle Field.

5. Mr. Klara, your testimony mentions injecting carbon dioxide into fractured shale formations in North Dakota—do we know whether or not those formations can effectively store carbon dioxide without leaking?

Response 5. The primary geologic storage options that are being considered for carbon sequestration are saline formations, oil/gas formations, and unmineable coal seams. Geologic storage capacity estimates generally include only these options. As research continues to unfold, several geologic storage options related to basalt formations and shale formations may emerge as potential storage candidates. These storage options are beginning to be investigated as potential options for safely and permanently storing carbon dioxide, and conclusive results verifying their effectiveness are still several years away.

Mr. COSTA. Thank you very much, Mr. Klara, for your testimony.

Let me begin the questioning. The Department of Energy released a study, I guess, recently on America's unconventional fuels that recommend investigation of assessment of potential fiscal incentives to encourage the investment of CO_2 for EOR projects.

Is the Department doing this since they released the report? And are there any results that you can speak of?

Mr. KLARA. Yes. The Department is still studying those efforts, and studying those issues. And several reports have been released, or are in preparation, relative to looking at the potential for CO_2 EOR throughout the United States, and through numerous basins that are called geologic basins. And I would be happy to give you a status on those after the hearing.

Mr. COSTA. All right. Several times in your testimony you talked about various studies that were being done with Advanced Resources International. When do you expect those evaluations to be finished?

Mr. KLARA. We have several of those that are already developed and finished, and we would anticipate most of those being done over the course of the next, say, nine months to a year.

Mr. COSTA. And how about in the year of enhanced gas recovery, or the enhanced coalbed for methane recovery? Is there any research being done in those two areas?

Mr. KLARA. Yes. The majority of that research right now is being done in the carbon-capture and storage area, where we are looking at the use of carbon dioxide in coalbeds, for example, to enhance gas recovery of coalbed methane.

Mr. COSTA. And where is the Department of Energy in carrying out the enhanced oil recovery demonstration program that was mandated in the previous legislation that was noted, Section 354 Energy Policy Act of 2005?

Mr. KLARA. I would have to get back to you on that, sir.

Mr. COSTA. Please do.

Mr. Spisak, does the BLM see carbon-dioxide enhancement oil recovery as a significant component of our future production for Federal lands? And if so, what percentage, or how would you describe its role in the future?

Mr. SPISAK. I think there is significant potential there. There are a number of depleted oilfields, or partially depleted oilfields on Federal lands, that might be candidates for carbon sequestration. But as was mentioned earlier, each case would need to be evaluated separately. And I think we are ready to assist in that.

As you are aware——

Mr. COSTA. Has the Bureau of Land Management begun undertaking that assessment?

Mr. SPISAK. We primarily provide access to others to develop, and that is our expertise, if you will. We have regulations in place that we believe can deal with, dealing with rights-of-way for CO_2 pipelines, and the planning side. But our regulations primarily allow us to authorize CO_2 injection for enhanced oil recovery only.

Mr. COSTA. OK. But let me ask it to you in a different way, I guess, and that will be a subject, I guess, of the next panel. But has industry that has participated in these fields, have they come to you folks indicating that there is a stronger interest, given the current energy crisis that we are facing, and the cost of fuel, to pursue these older fields?

Mr. SPISAK. We are starting to see that, through our sundry notices, where companies will ask that a well be shut in for potential CO_2 conversion at a later date.

Mr. COSTA. One of the concerns that has been raised, even though I believe this is kind of a win-win situation, that the carbon sequestration, that possibly the carbon dioxide might leak out of old well bores. Does the BLM, are they attempting to get a handle on this, on location and status of abandoned wells on public lands?

Mr. SPISAK. Well, part of Section 349 of the Energy Policy Act required us to inventory orphaned and idled wells, and prioritize those lists. And we have actually started that process. And so we have a better idea of the numbers of those types of wells that we have in our inventory.

Mr. COSTA. My final question to you, Mr. Spisak. In 2006 the Department of Interior concluded that the royalty relief for oil produced from industrial carbon dioxide was not warranted. Why was that?

Mr. SPISAK. Well, we have existing regulations that allow us, on a case-by-case basis, to allow royalty reductions to help promote that type of activity. And we felt like we could always open up that issue in the future, if necessary.

Mr. COSTA. Are companies telling you that there are any complications under the existing mineral leasing laws and regulations that would create more difficulty if they convert to a current EOR project on Federal lands?

Mr. SPISAK. We haven't been hearing anything along those lines at this point.

Mr. COSTA. My time has expired, so I will now defer to the gentleman from New Mexico, Mr. Pearce.

Mr. PEARCE. Thank you, Mr. Chairman.

Mr. Spisak, you heard the Chairman say that there are 10,000 APDs that are not being utilized. I am looking at a chart that shows in 2001, we had protests filed on 17 percent of the parcels which are offered for development. That number has increased to 58 percent today, 81 percent in the Rocky Mountains alone.

Do you find that, do you see that in real life, that we are actually finding protests, maybe three to four times higher? And would that be a reason that we are not producing in some areas?

Mr. SPISAK. Well, protests are typically at the lease-issuance or offering stage. The number of APDs and the number that are actually acted upon need to take into consideration that APDs now, with the updated onshore order, there is two years' period of time for the companies to be able to use them, which could be extended to another two years. And a lot of it depends on various timing restrictions that are in place. And so that the companies have to work that into account, as well as rig availability, which is, with the big run-up, companies are scrambling to get rigs either built and crews to be able to utilize the APDs that are in the pipeline.

Mr. PEARCE. OK. You have a lot of——

Mr. COSTA. If the gentleman would yield, and I won't count it against you. But on the number I used, and I will be happy to double-check it, but those 28,000 application of permits to drill have been approved, so they are not under protest.

Mr. PEARCE. Thanks. Now, we were talking about the carbon sequestration and the use in the EOR, like the infrastructure already exists, Mr. Spisak. Is that accurate, that we would use the same infrastructure to move carbon dioxide?

Let me hold up a map. I am visualizing the problem almost the same as our natural gas movements. In other words, we have to move carbon dioxide from where it was produced, somewhere.

And so I am wondering that front chart there—yes, this chart here—I am wondering if we are going to see a system of pipelines like that to carry carbon dioxide to the fields, and then carry the enhanced oil back out.

Mr. SPISAK. As mentioned in my testimony, the issue of infrastructures such as pipelines, right now the pipeline network is to deliver natural gas away. And those aren't necessarily going to be the pipelines that could deliver CO_2 to——

Mr. PEARCE. Right. So what kind of a permitting process are we talking about? If, I mean, we have to take carbon from everywhere in the country, take it in, gather it up, and then send it to some processing plant, and then back out to the oilfields? What sort of permitting problems do we face, just getting those pipelines to convey the CO_2?

Mr. SPISAK. Well, as is anything when the level of activity is, as it increases, we have a certain workload, workforce that is able to process——

Mr. PEARCE. To get this done in the next 10 years. Could you get the permitting done with the current workload?

Mr. SPISAK. We are pretty full up as it stands now.

Mr. PEARCE. OK. So what I am saying is that it is not like they are available.

Mr. SPISAK. Correct.

Mr. PEARCE. Mr. Klara, I noted in page 4 of your testimony you talk about DOE as significantly advanced, enhanced oil recovery. Can you tell me the contributions that DOE has made on this?

Mr. KLARA. Yes. A few examples——

Mr. PEARCE. Just very brief, because we need to move on to another question.

Mr. KLARA. Yes. A few examples. For example, CO_2 bypasses a key issue that limits the effectiveness of CO_2. And there has been a lot of research done, and additives to carbon dioxide.

Mr. PEARCE. Can you move the mic a little bit closer?

Mr. KLARA. There has been a lot of research done with additives to carbon dioxide and other additives in the reservoir to get a more effective flood-front of carbon dioxide.

In addition, there has been a lot of work on things like reservoir management strategies and using new well techniques, like horizontal wells.

Mr. PEARCE. These are DOE-sponsored events, not companies that are using their own resources. These are DOE advancements?

Mr. KLARA. DOE certainly has been a part of many of those advancements.

Mr. PEARCE. That wasn't quite my question, but I will move on.

You mention on page 2 that the global warming is significantly linked to carbons, CO_2, methane, nitrous oxide, everything else in the environment. What is your professional opinion on why the polar icecap tripled in size this last winter? Why did we have the coldest winter on record in most of the northern hemisphere? Why did we have ice in Vietnam when I was there? In 1971, 1972, and 1973 I didn't find ice anywhere; and yet we had ice for almost 30 days in Vietnam.

The carbon has decreased in our atmosphere. Exactly what is your professional opinion on this sudden reversal in our climate?

Mr. KLARA. Well, sir, I am not a climate-change expert, so I am going to——

Mr. PEARCE. OK. You put it in your testimony. So when you start using words that you can't—I mean, there are questions that are raised significant on this very point. So when you use statements like that in your testimony, it gives the appearance that you are experienced, and you can give data about that. And I think it is a very significant question. If you would get somebody in your agency to answer that question, I would appreciate that.

Mr. KLARA. OK, we will do that.

Mr. PEARCE. OK, thanks. I see my time has gone, Mr. Chairman. If we do two rounds, I have another series.

Mr. COSTA. All right. The gentleman from New Jersey is next, Mr. Holt.

Mr. HOLT. Thank you, Mr. Chairman. And thank you for setting up this hearing.

Let me ask, what are the major areas of research? I am trying to get a sense of the scale of the investment that is necessary for research into all aspects of using public lands for sequestration of the carbon. You have to look at the leakage, how extensive is it to study that; you have to look at the feasibility of transportation of the carbon dioxide, and so forth.

Has someone mapped out a long-term research, or short-term even, research plan? I suppose Mr. Klara would be the best person to start with, but I welcome comments from Mr. Spisak, also.

Mr. KLARA. We have a program within the Department of Energy, our Fossil Fuel Research Program, that is dedicated to developing the technologies to try to make that happen. And we have numerous goals and issues throughout our program over the course of up through 2020 and 2025, for example, that will hopefully set the stage for commercial availability of emerging technologies.

Relative to enhanced oil recovery and using CO_2, I think there are several key issues. First, you need mature fields, and the United States happens to have that happening automatically. Second, you need cheap sources of carbon dioxide. And relative to human activities and anthropogenic CO_2, you need cheap sources of anthropogenic CO_2. So a significant portion of the research program is looking at reducing the cost of CO_2 capture from energy facilities like power plants, looking at developing best practices and protocols for carbon storage and underground formations, to ensure it is permanent and safe. And those are some of the key aspects of the research program.

Mr. HOLT. And as this is mapped out, I mean, would it all be done by the Energy Technology Laboratory? Or is this, I am trying to get a sense of the scale of the investment that is necessary, public and private, to determine whether this is going to be a reality.

Mr. KLARA. In Fiscal Year 2008, the research budget for the coal program, for example, is in the neighborhood of $500 million. And most of what we do in the coal program is dedicated toward future energy power-plant configurations to deal with the CO_2 issue.

And we believe that, I believe that sustained investment is required for us to——

Mr. HOLT. You are saying most of the $500 million goes into studying sequestration of the carbon?

Mr. KLARA. No, no, no. Don't——

Mr. HOLT. That is what I am asking about, for the sequestration of the carbon.

Mr. KLARA. Right. Our carbon sequestration program alone is in the neighborhood of $120 million for Fiscal Year 2008. And what I meant by the comment of linking it to the entire research program was that whether you are looking at gasification of fuel cells, advanced turbines, all of those development efforts have in mind future plants that have to do with the CO_2 issue. So there is aspects within all of those program elements that are concerned about future configurations that deal with CO_2 capture.

Mr. HOLT. Does BLM have a research program?

Mr. SPISAK. No, I wouldn't characterize what we do as research. It is more land management access, working through how they would implement such research on the ground.

Mr. HOLT. OK. Mr. Spisak, if there were more extensive use of carbon for enhanced oil recovery, what would be the environmental effects that you have identified, other than pipelines? To the extent that pipelines would have environmental effects.

Mr. SPISAK. Injecting the fluid into the ground, like other fluids, water is a fairly I would say routine matter when it comes to enhanced oil recovery with CO_2 injection.

CO_2, when it does mix with water, can have some corrosive aspects. But I wouldn't expect that those types of environmental concerns are any more dangerous than the types of things we deal with every day.

Mr. HOLT. And quickly, Mr. Klara, if it can be answered quickly, how does one study leakage of carbon dioxide from coal seams or oil, depleted, or partially depleted oil areas? How do you study that, actually?

Mr. KLARA. The key there is to develop the suite of monitoring technologies that will allow you to look at the migration of carbon dioxide in the underground strata, at the surface, as well as even aerially. So there are some aerial technologies, plane flyover technologies, for example, that can look for leakage.

So the key there is a whole portfolio of imaging technologies that is applied to a carbon storage location that will allow you to essentially look at nearly all of the carbon dioxide, and know where it is at given period of time.

Mr. COSTA. The gentleman's time has expired. Thank you.

The gentlemen from Louisiana, Mr. Scalise.

Mr. SCALISE. Thank you, Mr. Chairman.

Mr. Spisak, how often do companies file an application for a permit to drill, but never, in fact, develop that, or drill?

Mr. SPISAK. I don't have a specific answer, but to say, but we find that over a four- or five-year period, about 75 percent of the APDs that are filed are eventually drilled. This is based on a study of looking at APDs back in 2004/2005.

Mr. SCALISE. Over a five-year period roughly, then.

Mr. SPISAK. Right.

Mr. SCALISE. What would be a reason that someone would file the application, get the permit, but the not drill?

Mr. SPISAK. One example might be they might drill a well; they might find that the downhole was different than they were expecting, and some of the other APDs in the pipeline that they had approved may not be appropriate for that development.

It could be that there is time constraints on seasonal restrictions for winter or deer cabin, or whatever it might be, closes the window down that they are able to drill the wells that they are needing, and so they have to push them off in time.

Another may be that they have a certain amount of rig availability to deal with the APDs that they have, and they are not able to get enough rigs or rig crews in there to drill the APDs that they have.

Mr. SCALISE. I don't have any more questions. That is all I have.

Mr. COSTA. OK. All right. I am going to use the discretion of the Chair at this time. We have had one round of questions, and I will ask the Committee members to submit any written questions, if you have any additional questions, and move on to our second panel.

Thank you very much, gentlemen, for your testimony and your prompt response on the answers. And as we are waiting for the other witnesses to come forward for the second panel, we will try to get through their testimony as best we can, hopefully before the votes are called, at which point we will have to recess and go to the Floor. And that will take about 40 minutes. That will be a

break for all of you here in the audience and all of you participating. And then we will come back and resume the hearing where we left off.

So thank you, gentlemen. And I will take this time, as our second panel is coming forward. The lady that is standing up is Holly Wagenet. You can acknowledge, wave to everyone, Holly. This is her last hearing as a part of the Committee. She has applied to law school, and she is going to go there, and I suspect she will do well, as she does in every other effort. We want to thank you for all the nice work you have done on behalf of the Subcommittee. And Holly Wagenet is being replaced by the lady next to her, Marcie Cooperman. Raise your hand, Marcie. So we want to make sure she is part of our able staff, to do a good job. And we thank them for their hard work, and wish you the very best, Holly. Yes.

[Applause.]

Mr. COSTA. She told me not to do that yesterday, so what can I say?

Anyway, we have five witnesses here. And let us begin first with Mr. Tracy Evans, in our second panel. He is the Senior Vice President of the Reservoir Engineering with Denbury Resources, Inc. Mr. Evans.

STATEMENT OF TRACY EVANS, SENIOR VICE PRESIDENT OF RESERVOIR ENGINEERING, DENBURY RESOURCES, INC.

Mr. EVANS. Thank you, Chairman Costa, Ranking Member Pearce, and members of the Subcommittee for the opportunity to share our views on enhanced oil recovery utilizing carbon dioxide, or CO_2 EOR.

Denbury's primary focus is enhance oil recovery utilizing CO_2, and we believe it can play an important role in meeting America's future energy needs, and helping to reduce greenhouse emissions.

As Denbury's Senior Vice President, I oversee all reservoir engineering, land, property acquisitions, and purchases of anthropogenic or manmade CO_2 volumes.

We are currently the largest oil producer in the State of Mississippi, and one of the largest injectors of CO_2 in terms of volume in the United States. Since 1999, we have produced over 20 million barrels of oil from CO_2 flooding from 10 active EOR projects in Mississippi and Louisiana.

Currently we utilize 550 million cubic feet, approximately 32,000-plus tons, of new CO_2 each day to produce about 24,000 gross barrels of oil per day. All this CO_2 comes from a natural deposit that we currently own. Although large, this supply is enough that it could supply us with up to 800 million cubic feet of additional CO_2, and the discussions to acquire additional volumes, as well.

It is important to note that we plan to purchase this anthropogenic CO_2. Thus, unlike the straw freely provided by the king in the tale by the Brothers Grimm, CO_2 is not free; and in fact, its price typically varies proportionately with the price of oil.

Also, unlike spinning straw into gold, CO_2 generally must be transported significant distances from natural or anthropogenic sources to oilfields, and injected to produce incremental volumes over 20 to 30 years.

We currently operate three pipelines in operation, distributing CO_2 from our natural source at Jacksonville, Mississippi, to our oilfields with a combined length of around 350 miles. Our biggest single project during 2008 and 2009 will be the construction of a $750 million, 314-mile, 24-inch pipeline to transport CO_2 from southern Louisiana to southeast Texas. The primary purpose of this pipeline is to capture anthropogenic volumes of CO_2.

The potential construction of gasification plants with the numerous additions to deplete oilfields along this route make this region attractive to additional CO_2 EOR. Thus, CO_2 EOR is a long-term capital-intensive endeavor. Nonetheless, we believe it has enormous potential in the near term to help address the urgent, often conflicting goals of increased energy security and lower greenhouse gas emissions.

At the present time, CO_2 injections for the purposes of CO_2 EOR total approximately 2 billion cubic feet per day; and generally in three regions of the country: West Texas, Mississippi, and Wyoming. All other oil-producing regions of the country could and would benefit from CO_2 EOR. Unfortunately, these areas do not have sufficient CO_2 supplies.

We estimate that if enough CO_2 were available in all producing regions of the country, we could inject upwards of five to six times the current amount of CO_2 being injected. To put this in perspective, this additional CO_2 volume is equivalent to approximately 40 typical gasification projects that would produce around 200 million cubic feet per day per project. Thus, if such projects can get off the ground, the potential for additional oil production using CO_2 EOR is significant.

I will now briefly address two obstacles to increasing EOR production and carbon sequestration: The cost of capture and transportation, and the lack of clear tax rules applicable to pipelines carrying anthropogenic CO_2.

Perhaps the single-largest obstacle developing carbon-capture, transportation, and sequestration beyond the limited number of projects currently in operation is the significant costs involved. The cost of capture stems from the variations in the quantity and the quality of CO_2 produced by hydrocarbon combustion or gasification, or other industrial processes, as well as the cost of purchase and power of the compressors necessary to pressure up the gas sufficiently to enter a pipeline in order to get it to a sequestration site.

Transportation costs are also significant. Insulation costs for CO_2 pipelines have increased in recent years from about $30,000 per inch-mile for Denbury's free-state pipeline to an estimated $100,000 per inch-mile for the planned green pipeline in southern Louisiana, primarily due to rising steel prices, rising energy prices, and construction costs, effectively doubling our CO_2 transportation rate. Without some means of reducing the cost of CCS infrastructure, development will likely remain stagnant.

Certain committees and Members of Congress have already taken steps to address cost issues, and to remove obstacles to infrastructure development. For example, one year ago the Senate Finance Committee approved a clarification of the tax treatment of income from pipelines for transporting anthropogenic CO_2.

A substantial portion of CO_2, natural gas, or products pipelines in the U.S. are owned and operated by publicly traded partnerships, whose reduced costs of capital lowers the costs of development and transportation of natural resources. However, due to the current uncertainty of the Tax Code, much of the existing CO_2 pipeline capacity cannot be used, and new capacity may not get built to transport anthropogenic CO_2 from emission sites.

The Senate Finance Committee approved language to remove this uncertainty. This Congress ultimately failed to include it on the Energy Independence and Security Act.

To conclude, the U.S. economy will continue to require massive amounts of energy well into the future. CO_2 can and should play an important role, helping to reduce dependence on imports. We can increase substantial volumes of domestic oil. And CO_2 EOR is also the only currently active on-the-ground of CO_2 injection and sequestration. And I look forward to answering any questions you may have.

[The prepared statement of Mr. Evans follows:]

Statement of Ronald T. Evans, Denbury Resources, Inc.

Denbury Resources, Inc., ("Denbury") appreciates this opportunity to share with Members of the House Subcommittee on Energy and Mineral Resources its experience with enhanced oil recovery using carbon dioxide or "CO_2 EOR." CO_2 EOR presents significant opportunities to reduce the nation's dependence on foreign energy sources while simultaneously helping to reduce industrial emissions. With the right policies in place, many billions of barrels of oil are accessible on the Gulf Coast and around the United States and millions of tons of CO_2 can be sequestered through CO_2 EOR. However, some impediments exists—primarily tax and economic—to capturing and transporting CO_2 on a broader scale in order to inject it and produce these significant volumes of domestic oil.

As Senior Vice President, Reservoir Engineering, for Denbury, I oversee all reservoir engineering, land functions and acquisition activities; am responsible for securing and contracting sources of anthropogenic CO_2; and coordinate our government relations. Denbury is currently the largest oil producer in the State of Mississippi and one of the largest injectors of carbon dioxide in terms of volume in the United States. Denbury's primary business focus is enhanced oil recovery utilizing CO_2. At the present time we operate ten (10) active CO_2 enhanced oil projects, nine in the State of Mississippi and one in the State of Louisiana.

Denbury also owns the largest natural deposit of CO_2 east of the Mississippi River, called Jackson Dome in central Mississippi, which we extract and transport through approximately 350 miles of dedicated CO_2 pipelines for use in EOR. Denbury is currently in the process of designing or constructing an additional 375 miles of CO_2 pipelines in order to expand our operations into additional fields throughout the Gulf Coast of the United States. The Subcommittee may also be interested to know that Denbury is working with the federal Department of Energy and various research universities on several Phase II and Phase III demonstration projects in the Regional Carbon Sequestration Partnership Program. Finally, while our business model focuses primarily on the transportation and sequestration aspects of carbon capture and sequestration ("CCS"), we are also very familiar with the capture component both in terms of (1) the compression demands of transportation and sequestration and (2) our enhanced oil operations, which capture and recycle large volumes of CO_2 in order to recover additional volumes of oil. Given this background, Denbury is pleased to share with you its expertise in CO_2 EOR and its views on policy implications for the nation's energy security and efforts to reduce industrial emissions.

A thorough understanding of both (1) the physical processes by which CO_2 is obtained, transported and injected for purposes of EOR, and (2) the economics that underlie existing and future EOR-related use of CO_2 is essential to any consideration of potential policy issues. The costs associated with capturing and transporting CO_2, whether in the context of EOR or otherwise, are significant and varying and—perhaps the single largest obstacle to developing carbon capture and transportation infrastructure beyond the limited, discrete projects currently in operation. From Denbury's perspective, it is critical that any contemplated state or federal legislation

or regulation not increase these costs and impede private sector development of the infrastructure necessary to meet the demands of our energy hungry and potentially carbon-constrained world.

I. Capture / Compression

The starting point for any CO_2 EOR project is to produce or capture the CO_2. Denbury currently obtains all of its CO_2 from its natural deposit at Jackson Dome. Certain existing and some evolving technologies allow CO_2 emitted from various manufacturing processes to be captured. The combustion or gasification of hydrocarbon-based fuels such as coal, petcoke or other hydrocarbons produces particularly large volumes of CO_2 at varying levels of quality and purity. As new capture-inclusive projects are constructed, Denbury plans to acquire thousands of metric tons of CO_2 each day for use in EOR.

Aside from the threshold questions of how to properly classify CO_2 and whether and to what extent to restrict emissions, from Denbury's perspective, the capture of CO_2 presents no significant policy issues. Rather, the capture component presents a significant economic issue: First, existing capture technology is expensive. The byproduct of hydrocarbon combustion or gasification is a stream of gases and other impurities that contains various quantities of CO_2. In order for CO_2 to be usable in EOR it must be injected in a relatively pure form. Similarly, CO_2 injected into deep saline reservoirs must be in a relatively pure form to maximize the storage space available to be filled with CO_2. Thus, a significant component of the capture cost is the cost to separate and purify the CO_2 to be injected. The lower the percentage of CO_2 in the stream of gases, and the greater the amount of impurities in the stream, the greater the cost of capture. Second, most technologies capture the CO_2 at a lower pressure than is required to either enter a typical CO_2 pipeline or to inject into a deep saline reservoir or EOR project. The costs of the compressors and the power necessary to drive them are significant—approximately $7.50/ton of the estimated $20/ton total cost [1] for CO_2 that is transported moderate distances. Therefore, the compression costs associated with CO_2 capture are slightly more than one-third (33%) of the total CCS cost for the least expensive sources of anthropogenic (man-made) CO_2. Additional compression costs are incurred to maintain pressure in pipelines and again when CO_2 is pressured up to a sufficient level for EOR reservoir injection. In summary, without some means of reducing the cost of captured anthropogenic CO_2 significantly, infrastructure development will likely remain stagnant.

To address this issue, last year the Finance Committee approved a tax credit for the capture and sequestration of CO_2 of $10.00/ton in connection with EOR and $20/ton for non-EOR projects for up to 75,000,000 tons sequestered. From Denbury's perspective, this would be sufficient to incentivize construction of additional pipelines from emission sites to geologic sequestration sites in connection with EOR activities. Unfortunately, this provision was not included in the energy legislation ultimately signed into law in December. We hope that Congress will address the issue of CCS costs in 2008, especially those associated with capture and compression, and note that proposed projects from gasification through to sequestration have the potential to create hundreds and perhaps thousands of jobs across the country.

II. Transportation

The most economical way to transport CO_2 is through pipelines at pressures in excess of 1100 psi so that the CO_2 is transported as a supercritical fluid (dense phase). At pressures in excess of 1100 psi and temperatures common for CO_2 pipelines, CO_2 is a supercritical fluid which means that the CO_2 has properties of both a liquid and a gas. Larger volumes of CO_2 can be transported through CO_2 pipelines in this dense phase than can be transported as a gas. Given the pressure requirements to maintain CO_2 in the dense phase, CO_2 pipelines are generally operated at pressures greater than 2,000 psi. This pressure is well in excess of the average operating pressure of a natural gas pipeline, though the material used to manufacture both types is the same.

At the present time there exist over 3,500 miles of dedicated CO_2 pipelines, most of which have been transporting CO_2 for over 20 years—and some for over 30 years. (see Attachment No. 1) However, this is just a fraction of the pipeline network that exists for oil and natural gas and covers very limited geographic areas. The vast majority of CO_2 pipelines transport natural CO_2 from natural underground CO_2 production sources that are owned and operated by the CO_2 pipeline owner—generally for use in enhanced recovery projects also owned and operated by the CO_2 pipeline

[1] Total costs of CCS varies substantially by source of CO_2—to upwards of $70/ton—and even across proposed gasification projects because of variances in each process. This figure represents an estimate of the lowest-cost industrial-sourced CO_2.

owner. In cases where the owner of the CO_2 pipeline has CO_2 production volumes in excess of its own EOR requirements, the excess CO_2 volumes are sold to EOR operators in other projects or to industrial gas suppliers. This limited number of regional CO_2 shippers and consumers stands in marked contrast to the numerous and geographically widespread producers and consumers of oil and natural gas products. As with the development of the extensive network of natural gas, oil and hydrocarbon products pipelines, CO_2 pipelines should also be given room to grow by state and federal regulatory authorities

The construction and installation of CO_2 pipelines is a capital intensive effort, the costs of which have increased in recent years for a variety of reasons, including rising steel prices, construction costs and energy prices. By way of example, Denbury's 93 mile, 20 inch Freestate pipeline (see Attachment No. 2) completed in 2006 cost approximately $30,000 per inch-mile, resulting in an effective transportation rate of approximately $3.50/ton at full capacity. The initial 37 mile segment of Denbury's 24 inch Delta pipeline was completed in 2007 at a cost of approximately $55,000 per inch-mile. We estimate that our planned 314 mile, 24 inch Green Pipeline that will run from Donaldsonville, Louisiana to Hastings field in southeast Texas will cost approximately, $100,000 per inch-mile resulting in an effective transportation rate of approximately $7/ton at full capacity. While the length (pumping stations to maintain adequate pressure add an additional $1 to $2 per ton to transportation costs), route obstacles and type of terrain all added to the estimated cost of the Green pipeline, the fact remains that such endeavors, even under the best of circumstances are extremely costly and take years of careful planning.

III. Taxation

Today, a substantial portion of all CO_2, natural gas, oil and products pipelines in the U.S. are owned and operated by companies that are organized as Publicly Traded Partnerships commonly referred to as Master Limited Partnerships ("MLPs"), which through their lower cost of capital have been an important financing source for building these assets. Section 7704 of the tax code permits MLPs to be taxed so that income and tax liabilities are passed through to the partners, even though the MLPs are large public entities, provided 90 percent or more of the MLP's gross income is derived from certain qualifying activities. These activities include exploration, development, processing and transportation of natural resources, including pipelines transporting gas, oil, or products thereof (see Sec. 7704(d)(1)(E)). While this provision covers the processing and pipelining of "natural" CO_2, it is unclear whether it covers anthropogenic CO_2. Because of this uncertainty, much of the existing CO_2 pipeline capacity (that owned by MLPs) cannot currently be used to transport anthropogenic CO_2 from emissions sites—at least not without significantly higher tax costs than other pipeline assets in the industry.

Last year, as part of its energy tax package, the Senate Finance Committee adopted a modification to include industrial source CO_2 in the definition of qualifying income (see Sec. 817 of the Energy Enhancement and Investment Act of 2007, June 19, 2007). However, Congress ultimately failed to include that package of provisions in the Energy Independence and Security Act of 2007 (P.L. 110-140). Without this modification of the tax code, a substantial portion of the pipeline industry will most likely not contribute capital to the construction of the CO_2 pipeline infrastructure necessary to facilitate CCS through transportation of anthropogenic CO_2. We strongly urge Members of the Energy and Mineral Resources Subcommittee to work with their colleagues on the Ways and Means Committee and their counterparts in the Senate to accomplish this important clarification.

IV. CO_2 EOR—Injection / Sequestration

Approximately half of the oil that has ever been discovered will remain in the reservoir following primary and secondary production operations. In the proper environment, enhanced oil recovery utilizing CO_2 has the ability to recover up to an additional 25% of the original oil in place or half of the remaining oil in place following primary and secondary operations. Enhanced oil recovery utilizing CO_2 requires multiple injection wells throughout a unitized field or reservoir. CO_2 injection wells are permitted and approved by each State's division or department of Underground Injection Control utilizing the standards and policies issued by the EPA. CO_2 injection wells utilized in tertiary oil recovery (a.k.a. EOR) are permitted and approved as Class II Injection wells. Such wells have been in existence for over 30 years. We believe existing laws and regulations provide sufficient protection of the fresh water and ground water reservoirs from the injection of CO_2 in EOR operations or, for that matter, in deep saline reservoirs.

At the present time, CO_2 injections for the purposes of CO_2 EOR total approximately 2 billion cubic feet per day (Bcf/d) in three regions of the country, West

Texas, Mississippi and Wyoming. Several other oil producing regions of the country could and would benefit from CO_2 EOR. Unfortunately, these other areas do not have naturally occurring CO_2 supplies. We estimate that if naturally occurring CO_2 were available in all oil producing regions in the country, CO_2 EOR could inject upwards of five or six times the current amount of CO_2 being injected. To put this in perspective, this additional CO_2 volume is equivalent to approximately 40 typical gasification projects (200 MMcf/d per project).

The amount of CO_2 injected in CO_2 EOR projects varies by oil producing area and project design. Although each project is different, the range of CO_2 injected to produce a barrel of oil is four to twelve thousand cubic feet (Mcf). In order to produce oil through CO_2 EOR, the injected CO_2 must physically contact the oil remaining in the reservoir. Oil remaining in the reservoir after secondary recovery operations cannot be recovered or produced unless the oil is physically altered. CO_2 dissolves into the oil causing the oil to swell, the viscosity to reduce and the surface tension (force holding the oil to the rock) to reduce, allowing the oil to become mobile. Due to reservoir heterogeneities and existing well spacing some oil is not contacted and thus these characteristics of each CO_2 EOR project are the limiting factor to recovering a greater percentage of the remaining oil. Further, CO_2 EOR, while applicable to a fairly wide range of reservoirs and oil gravities, is not applicable to all. Generally, in order to keep the CO_2 in the dense phase, a reservoir pressure in excess of 1,100 psi must be achieved, thus CO_2 EOR is generally conducted in reservoirs below 3,000 feet. In our opinion, CO_2 EOR is the most efficient tertiary recovery technology available today for reservoirs in which CO_2 EOR is applicable.

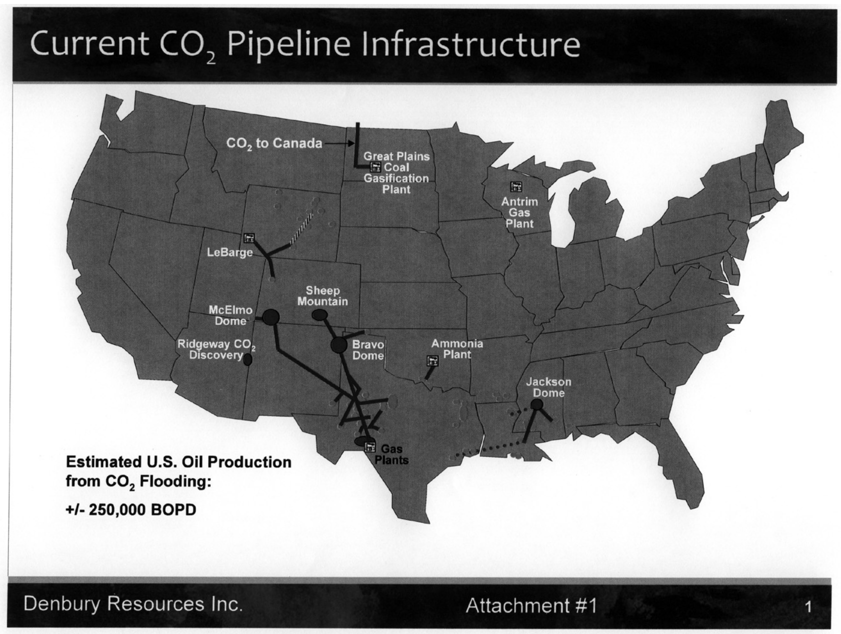
At the present time Denbury is injecting approximately 550 million cubic feet per day (MMcf/d) of CO_2 into its current CO_2 EOR projects and is planning on initiating injections into three additional CO_2 EOR projects in the near future which will increase our total injections to approximately 800 MMcf/d. Denbury has allocated essentially 100% of its proven CO_2 reserves to current and future projects that we own or have the option to purchase. Therefore we have been negotiating and contracting for anthropogenic volumes of CO_2 from proposed gasification projects and other existing anthropogenic CO_2 sources. We have signed three CO_2 purchase contracts to date totaling almost 800 MMcf/d of anthropogenic CO_2. These contracted volumes of anthropogenic CO_2, and others in negotiation, are necessary for Denbury to expand its CO_2 EOR operations to additional fields. These contracts also contain CO_2 pricing provisions that are tied to the price of oil, so as oil prices increase, the price paid for the anthropogenic CO_2 increases. These contracted CO_2 prices may or may not be sufficient to cover the CO_2 capture and compression costs depending on several variables including (existing and future) capture and compression costs, the price of oil, the CO_2 source, and the distance from the source to the CO_2 EOR project.

V. Conclusion

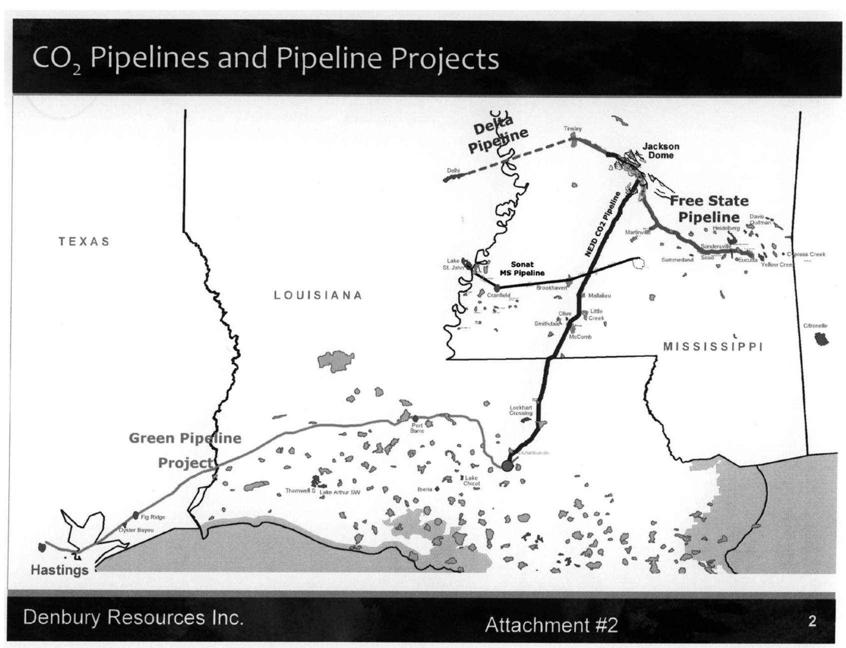
The U.S. economy will continue to require massive amounts of energy well into the future. We believe the country needs to use all of its resources to meet this demand. Given current environmental conditions, there is also a desire to sequester significant volumes of CO_2 from industrial sources. CO_2 EOR's ability to address both of these realities make it uniquely well-suited to play an important role in America's energy and environmental future. For this to happen, the federal government should help address the significant costs of capturing and transporting CO_2 as discussed above. The most important step Congress can take at present is to amend Section 7704(d)(1)(E) of the tax code to make clear that transportation of anthropogenic CO_2 is included. This will allow a significant number of industry participants to lead the way in developing the infrastructure necessary for a carbon constrained, energy dependent world. By providing necessary mechanisms to foster CO_2 EOR (whether on federal or privately owned land), and allowing states to continue to oversee its development, the U.S. can realize significant increases in domestic oil production and benefit from reduced industrial emissions.

Just as we believe the country needs to draw upon all of its vast resources to meet our energy requirements, we recognize that many different avenues must be explored and researched to exponentially reduce emissions. The EOR industry's experience with using CO_2 and its knowledge of oil reservoir geology should greatly facilitate the commencement of significant CO_2 sequestration today versus some distant time in the future. The substantial body of knowledge and expertise with CO_2 EOR that exists is why we believe it will be the primary method of sequestering CO_2 in the near term, while research is completed on additional technologies and geological formations. CO_2 EOR is not the sole answer to America's energy or environmental challenges. However, it can be a key part of solving this complex puzzle.

Attachment No. 1



Attachment No. 2



Response to questions submitted for the record by Tracy Evans, Senior Vice President of Reservoir Engineering, Denbury Resources Inc.

Questions & Responses

1. Mr. Evans, if the government enacted that fix to the pipeline tax code that you mention, how much investment do you think that would bring in from the private sector?

It is difficult to quantify with any certainty how much private sector investment would result from clarification of Section 7704 of the tax code with respect to anthropogenic carbon dioxide (CO_2). Denbury's expertise lies in tertiary oil recovery methods, and pipeline construction investment decisions depend on multiple factors in addition to tax policy. Nonetheless, such clarification would remove what is essentially a significant regulatory hurdle or disincentive to transporting man-made CO_2 volumes from emissions sites to enhanced oil recovery or saline injection sites via dedicated pipelines, the most efficient mode of transporting CO_2. Insofar as a major portion of oil, natural gas and CO_2 pipelines are owned and operated by publicly traded limited partnerships, Denbury Resources believes that removing this obstacle would have a substantial impact:

- Our review of the Oil and Gas Journal's 2007 Pipeline Construction Report (published by Penwell) indicates that 10,500 miles of pipeline projects were proposed or planned (primarily to transport oil and natural gas products) as of its publication in November 2007. Of that amount, 78% or 8,100+ miles are being proposed or planned by publicly traded partnerships.
- Our review of the Pipeline Journal's most recent annual ranking of the top pipeline owners and operators in the United States, indicates that publicly traded partnerships account for 66%+ of the top 20 liquid pipelines operators ranked by number of miles operated. (November 2007; data based on 2006 miles; Oildom Publishing Co.) These top 20 owners based on miles of liquid pipelines operated account for 66%+ of the total number, (91,120 miles of 138,037 miles), of liquid pipelines in the U.S. If so-called legacy pipelines owned by major oil and gas companies are removed, the percentage owned and operated by publicly traded partnerships increases to 96%+.
- Looking at the top 20 gas pipeline operators, which account for approximately 75% of all gas pipelines (234,275 miles of 312,586 miles) in the U.S., the percentage owned and operated by publicly traded partnerships is 43%+.

From the above, it is very evident that publicly traded partnerships own or operate a substantial portion of pipelines operating in the U.S. today and are constructing or planning to construct the vast majority of new pipelines. It is hard to envision how the enormous pipeline network required to effectively transport CO_2 for storage—via enhanced oil recovery, injection into saline aquifers, or otherwise—could be built without the resources, expertise and full participation of publicly traded partnerships. Such companies can hardly be expected to undertake the substantial effort and investment required to build CO_2 pipelines while uncertain of the tax treatment of any eventual income derived from the transportation of anthropogenic CO_2. CO_2 pipeline owner/operator Kinder Morgan has also called attention to this issue. (See testimony of Vice President Charles E. Fox before the Senate Commerce Committee's Subcommittee on Science, Technology, and Innovation, November 7, 2007.)

Further, due to their tax structure which results in lower costs of capital, publicly traded partnerships have historically been willing to accept lower rates of return on investment than public companies that are corporate entities. Thus, if publicly traded partnerships participate in the construction and ownership of CO_2 pipelines, the total cost of capturing, transporting and sequestering man-made CO_2 will be lower than would otherwise be the case. If Congress is determined to increase domestic production through CO_2 enhanced oil recovery (EOR) and to store CO_2 to reduce emissions, it should encourage the involvement of this key segment of the private sector by removing this uncertainty.

2. Mr. Evans, what federal and state EOR incentives is your company currently taking advantage of?

Section 43 of the Internal Revenue Code provides a 15% tax credit for capital investments made in CO_2 EOR projects. However, the credit is indexed to crude oil prices, which are now well above the maximum level at which the tax credit applies. Thus, Denbury utilizes some Section 43 EOR tax credits earned in prior years when crude oil prices were lower to offset federal taxes in the current year, but new Section 43 credits are no longer available

At the present time, Mississippi, Louisiana and Texas (areas where Denbury operates) all provide for reduced severance taxes on oil produced as a result of enhanced

oil recovery utilizing CO_2. While each state varies in the amount of severance taxes levied, Mississippi and Texas each grant a 50% reduction in the amount of severance taxes paid on oil produced through CO_2 EOR. Louisiana is different in that it grants a severance tax holiday (0%) until project payout is reached. In January 2008, Texas enacted a new regulation that grants an additional 50% (total of 75%) severance tax reduction for oil produced using man-made CO_2 in EOR applications.

3. Mr. Evans, your testimony mentions the tax credit for CO_2-*EOR that was almost enacted last year and says it would be enough to incentivize pipeline construction—would it also be enough to incentivize capture as well?*

The tax credit approved by the Senate Finance Committee last year was for carbon capture and sequestration (CCS), not for CO_2 EOR. The point of the credit is not to subsidize pipeline construction, but to defray the high costs noted in my testimony of separating, capturing and pressurizing anthropogenic CO_2. If capture costs—the most significant factor in total CCS costs—can be sufficiently reduced, the existing CO_2 pipeline backbone could be significantly expanded in connection with EOR activities in a cost-effective manner. At current market prices for crude oil, a tax credit for the capture and sequestration of CO_2 of approximately $10.00 per ton would lower total CCS costs sufficiently to encourage the capture of significant volumes of CO_2 from the lowest cost emissions sources (i.e. +/-$20/ton for ammonia and coal gasification.). A reliable supply of man-made CO_2 at a reasonable price, in turn, would encourage EOR end users to undertake the substantial investment required for construction of additional pipelines from emission sites to geologic sequestration sites. Thus, credits incentivizing capture would help create and match the CO_2 supply with EOR demand, from which the pipelines to link the two would follow. These pipelines could ultimately be used to transport and sequester additional volumes of CO_2 after the cessation of EOR operations.

As I testified at the hearing, Denbury builds and owns pipelines to transport CO_2 for use in its EOR operations. Denbury does not capture CO_2 from industrial sources, although it has entered into agreements to purchase CO_2 from projects that plan to capture it. So far, these projects—and many others that envision capturing CO_2 emissions—have not started construction. The proposed tax credit could help advance many of these projects, namely those with the lowest estimated costs of capture, by addressing a major cost component. A larger credit may help advance additional projects—those with slightly higher capture costs.

Senators Kent Conrad and Orrin Hatch recently introduced legislation (S. 3208) that contains a new version of the tax credit. The credit as structured in this bill would range from $15-$30 per ton of CO_2 captured and sequestered and would be effective for ten years. Denbury supports these modifications and urges members of the Subcommittee to work with their colleagues to pass companion legislation in the House of Representatives.

4. Mr. Evans, what sort of production levels do you think we could see from CO_2-*EOR over the next 10 or 20 years? Could we reach 1 million barrels per day? What would it take to make those sort of production levels a reality?*

Assuming access to sufficient supplies of CO_2 at reasonable prices in all oil producing regions of the country, I believe the United States could eventually reach production from CO_2 EOR of up to 2 million barrels per day. It is difficult to estimate a time frame since that depends on many variables (rates of construction, labor costs, materials costs, etc.), but +/-20 years is reasonable. I arrive at this estimate as follows:

The maximum rate of oil production the United States can expect from CO_2 EOR depends on many factors, primarily the availability of CO_2 at reasonable costs. CO_2 EOR is applicable to all oil producing regions of the country but not to all oil producing reservoirs in each region. As discussed at the hearing, the success of CO_2 EOR in a given reservoir depends on multiple factors such as reservoir depth, gravity of the oil, purity of CO_2 stream, reservoir temperature, reservoir pressure, reservoir heterogeneity and other factors.

Denbury has successfully utilized CO_2 EOR in one oil producing region of the country with the only known naturally occurring significant source of CO_2 east of the Mississippi River. When comparing our CO_2 EOR volumes (an estimated 24,000 gross barrels of oil per day) to the current daily total volume of oil production in the State of Mississippi (based on U.S. Energy Information Administration estimates for January 2008), CO_2 EOR is in excess of 42% of Mississippi's total production. With Denbury's future additional projects, CO_2 EOR will eventually exceed 50% of total production in Mississippi.

The Permian Basin of West Texas has the greatest number of existing CO_2 EOR projects—more than any other oil producing basin in the country. It is estimated

that total current oil production from CO_2 EOR projects there is approximately 200,000 gross barrels per day while total daily production from all forms of oil production in the basin is approximately 678,000 barrels per day according to IHS, Inc., which maintains an industry production database. Thus, approximately 30% of the oil production from the Permian Basin is being produced through CO_2 EOR.

Applying the overall level of success with CO_2 EOR in these two regions—30% to 50% of total production—to current U.S. oil production, which averages approximately 5 million barrels per day (a reasonable, useful analogy based on what we know of other oil-producing regions), would yield 1.5 million to 2.5 million barrels per day. Since it is unlikely that man-made CO_2 will be delivered to all producing oil basins at the same time, I believe it's appropriate to reduce these figures by 20%. Thus, my estimate of potential additional oil production from CO_2 EOR is 1.2 million to 2.0 million barrels per day.

As stated at the outset, this estimate assumes access to sufficient supplies of CO_2 at reasonable prices in all oil producing regions of the country. Reliable access to such supplies is what would it take to make these sort of production levels a reality. My answers to questions 1 and 3 above describe policies that, if adopted by Congress, would facilitate this.

Mr. COSTA. Thank you very much, Mr. Evans.

Our next witness is Mr. William Roby, Vice President of Worldwide Engineering and Technical Services for Occidental Oil and Gas Companies.

Mr. Roby, please.

STATEMENT OF WILLIAM ROBY, VICE PRESIDENT, WORLDWIDE ENGINEERING AND TECHNICAL SERVICES, OCCIDENTAL OIL AND GAS CORPORATION

Mr. ROBY. Thank you, Chairman Costa.

Mr. COSTA. The five-minute rule applies to all of you, just like the previous panel.

Mr. ROBY. Thank you. Thank you, Chairman Costa, members of the Energy and Mineral Resources Subcommittee, and other guests.

My name is William Roby. I am Vice President of Worldwide Engineering and Technical Services for Occidental Oil and Gas Corporation.

I greatly appreciate the opportunity to speak today regarding both Occidental's use of carbon dioxide to enhance the recovery of oil and associated gas in the United States, and some of the emerging policy issues related to enhanced oil recovery.

These issues are of great importance to the nation, particularly as demand grows, and we seek ways to increase domestic production of oil and natural gas in this country, while reducing the concentration of CO_2 in the atmosphere.

By way of background, Occidental Oil and Gas Corporation is a Los Angeles-based oil and gas exploration and production company, with operations in the United States, the Middle East, North Africa, and Latin America. Sixty-three percent of Occidental's 2007 production occurred in the United States, and 75 percent of our proven reserves are located in the United States.

Enhanced oil recovery techniques have substantial economic and environmental benefits, and can significantly increase oil recovery. As a result, oil that would have been left in place is producible, and contributes directly to our domestic supply. Its use is being good stewards of our country's precious energy resources.

In addition, CO_2 EOR is a viable method for reducing greenhouse gases by reusing and storing CO_2 underground from industrial and power-generation facilities.

CO_2 has been used for over 30 years in the Permian Basin in West Texas, and New Mexico to enhance oil recovery. Since that time, Occidental has become the largest user of CO_2 injection for EOR in the world. And CO_2 flooding is our most commonly used EOR technique.

Through CO_2 flooding, the fields Occidental operates in the Permian Basin will produce over 1 billion barrels of oil more than would have been produced without this technology. Our experience shows that CO_2 flooding has increased the ultimate oil recovery by an average of nearly 25 percent.

We now operate over 8,700 wells in 28 CO_2 EOR projects in Texas and New Mexico. We have nearly 3,700 CO_2 injection wells that support 5,000 producing wells, and we inject approximately 1.4 billion cubic feet of CO_2 each day, or 500 billion cubic feet per year, in the Permian Basin alone.

However, using CO_2 to enhance oil recovery is technically challenging and costly. Some oil formations are not amenable to CO_2 injection, and all depend on geologic structure, permeability, and homogeneity of the formation. Additionally, oil production response sometimes takes many months to occur. We estimate that using CO_2 to enhance oil recovery increases the cost per barrel of oil by more than 50 percent over typical secondary recovery operations.

Notwithstanding the cost, we believe using CO_2 to increase oil recovery is an extremely important technology for meeting our national energy needs, and Occidental encouraged Congress to develop policies and incentives to increase its use. National policies and incentives to promote CO_2 injections could significantly increase proven oil reserves. Increasing domestic reserves has additional benefits, including extending the life of aging reservoirs, increasing tax and royalty revenues for the public, increasing employment opportunities to operate the fields, and providing greater domestic supplies of energy.

The committee specifically asked for suggestions on how to foster further use, and remove impediments to the expansion of CO_2 enhanced oil technology. Since CO_2 EOR is a costly business proposition, these projects require robust, long-term economics to incentivize producers to undertake the risks. We have the following suggestions.

Number one, investment incentives. We suggest you consider providing incentives such as investment credits, and accelerating depreciation of the project's capital cost, including infrastructure required to transport and inject CO_2.

Number two, royalty rates. We suggest that the government consider providing declining royalty rates on Federal leases where CO_2 EOR is used.

Number three, legal issues. Legal areas that warrant clarification include, one, confirming subsurface pore space as part of the mineral state; number two, predictable and defined rights and obligations relating to subsurface pore space ownership; and number three, the ability and easy modification of historic field unit agree-

ments to accommodate EOR operations, including potential unitization raised by sequestration of CO_2.

And last, clear expectations regarding the disposition of EOR wells and fields, including oilfield CO_2 sequestration sites.

However, we believe the current regulatory provisions and Permian regimes for conventional CO_2 EOR operations work very well, and provide thorough oversight by the regulators and opportunity for public input.

And I want to discuss the role CO_2 EOR technology can play on controlling greenhouse gas emissions. In particular, one of the benefits of injecting CO_2 for enhanced oil recovery is the ability to store significant volumes of CO_2 in the reservoir, both during and after oil and gas production. In typical EOR operation, approximately one-third to one-half of the CO_2 initially injected becomes trapped in the reservoir. The rest is recycled from producing wells as a valuable commodity, and reinjected.

As I mentioned earlier, Occidental currently injects approximately 500 billion cubic feet of CO_2 per year. To put this in context, each year the amount of CO_2 that Occidental injects is equivalent to the emissions of 10 150-megawatt coal-fired power plants.

We have 30 years of history using naturally occurring CO_2 from underground reservoirs. However, we just as easily could use CO_2 captured from emissions of electrical utilities, refineries, and other large sources if it were available at competitive prices.

We believe the key challenge to using manmade CO_2 and EOR operations are the costs to capture carbon dioxide from industrial-power generation sources, and the cost of building the infrastructure to transport the CO_2 to a field, and to compress it to the required pressure for injection into the reservoir.

Occidental believes that industrial CO_2 for natural recovery provides technical information, and demonstrates results for long-term CO_2 sequestration. In fact, this technology is a great way, is a gateway to future large-scale carbon sequestration; and the industry's 30-year history of using CO_2 provides the evidence it can be managed safely.

Mr. COSTA. Mr. Roby, we appreciate your testimony, and you have done a good job.

Mr. ROBY. Yes, that is my last comment. Thank you very much.

Mr. COSTA. Thank you.

[The prepared statement of Mr. Roby follows:]

Statement of William Roby, Vice President of Worldwide Engineering and Technical Services, Occidental Oil and Gas Corporation

Chairman Costa, members of the Energy and Mineral Resources Subcommittee and other guests, my name is William Roby. I am Vice President of Worldwide Engineering and Technical Services of Occidental Oil and Gas Corporation. I greatly appreciate the opportunity to speak today regarding both Occidental's use of carbon dioxide to enhance the recovery of oil and associated gas in the United States and some of the emerging policy issues related to enhanced oil recovery. These issues are of great importance to the Nation, particularly as demand grows and we seek ways to increase domestic production of oil and natural gas in this country while reducing the concentration of carbon dioxide in the atmosphere.

By way of background, Occidental Oil and Gas Corporation is a Los Angeles-based oil and gas exploration and production company with operations in the United States, the Middle East, North Africa and Latin America. Sixty-three percent of Occidental's 2007 production occurred in the United States, primarily in the states of

California, Texas, New Mexico, and Kansas. Seventy-five percent of our proven reserves are located in the United States.

Before I discuss Occidental's experience with enhanced oil recovery using carbon dioxide or CO_2, I want to briefly explain what I mean when I use the term "enhanced oil recovery." Enhanced oil recovery, or EOR, is a generic term for techniques that increase the amount of oil extracted from a reservoir beyond primary and secondary recovery methods. Primary recovery refers to production where the hydrocarbons in the reservoir flow into the well due to the natural pressure in the reservoir. Secondary recovery refers to production where the hydrocarbons flow into the well because pressure in the reservoir is increased by injecting fluids, such as water or hydrocarbon gas, typically already found in the reservoir. Lastly, enhanced oil recovery refers to production from injecting materials not normally found in the reservoir such as steam, CO_2 in large quantities, or other chemicals. These techniques are designed to increase reservoir pressure, reduce the oil's viscosity or alter oil's properties that cause it to be trapped in small pore spaces in the rock, thus improving oil's ability to flow through the reservoir and improve extraction.

Enhanced oil recovery techniques have substantial economic and environmental benefits. They can increase production from an oil reservoir by an additional 10% to 50% of the oil originally contained in the reservoir. As a result, oil that traditionally would have been left in place contributes directly to our domestic supply. Recovering more oil from existing fields with EOR uses far fewer resources than simply abandoning older fields and installing new infrastructure, such as roads, pipelines and equipment, for primary production in new locations. In addition to these benefits from all EOR techniques, EOR using carbon dioxide flooding is a commercially viable method for reducing greenhouse gas emissions by reusing and storing CO_2 underground that would otherwise be emitted from industrial or power generation facilities to the atmosphere.

Carbon dioxide has been used for over thirty years in the Permian Basin in West Texas and New Mexico to enhance oil recovery. Since that time, Occidental has become the largest user of CO_2 injection for EOR in the world, and CO_2 flooding is our most commonly used EOR technique in the Permian Basin. By using this technique, along with other new technologies, we have been able to substantially increase the productivity and lengthen the life of existing oil fields. Through the use of CO_2 flooding and other EOR techniques, the fields that Occidental operates in the Permian Basin will produce over one billion barrels of oil more than would have been produced without this technology. Our experience has been that CO_2 flooding has increased the ultimate oil recovery from the fields where we employ it by an average of nearly 25 percent. We now operate approximately 8,700 wells in 28 EOR projects in Texas and New Mexico utilizing CO_2 to increase oil production. We have nearly 3,700 CO_2 injection wells that support 5,000 production wells, and we inject approximately 1.4 billion cubic feet of CO_2 each day or 500 billion cubic feet per year in the Permian Basin alone.

Using CO_2 to enhance the recovery of oil is technically challenging and costly. Some oil formations are not amenable to carbon dioxide injection, depending on the geologic structure, permeability and homogeneity of the formation. For those fields where CO_2 injection is feasible, such as in the Permian Basin, we incur costs both to purchase or produce CO_2 and to acquire, operate and maintain the necessary above-ground processing equipment. Projects are capital intensive because they require extensive infrastructure to transport, compress, capture and recycle CO_2; operating costs, such as for additional electricity needs, are also high; and oil production response sometimes takes many months to occur. These costs add significantly to our total cost to produce a barrel of oil. We estimate that using CO_2 enhanced recovery at our Permian Basin operations increases the cost of recovering a barrel of oil by more than 50% over typical primary and secondary recovery operations.

Notwithstanding the cost, based on our experience in the Permian Basin, we believe the use of carbon dioxide to increase oil recovery is an extremely important technology for meeting our national energy needs, and Occidental encourages Congress to develop policies and incentives for increasing the use of this technology. Enhanced oil recovery using CO_2 has helped increase supplies from some of the Nation's most prolific fields. National policies and incentives to promote the use of carbon dioxide injection could significantly increase proven reserves of oil and gas in the United States. Increasing domestic reserves has many additional benefits, including extending the life and recoverable reserves of aging reservoirs, increasing tax and royalty revenues for the public, increasing employment opportunities to operate the fields, and providing greater domestic supplies of energy, all of which could, perhaps, reduce or forestall speculative exploration in undeveloped areas.

The Committee has specifically asked for suggestions on how to foster further use of carbon dioxide enhanced oil recovery technology and to strengthen our domestic

oil supply by removing impediments to the expansion of this technology. Since CO_2 EOR is a costly business proposition, these projects require robust long-term economics to incentivize the producers to undertake the risk. We have the following suggestions on ways to foster further use of this technology:

1. Investment incentives:—we suggest you consider providing incentives such as investment credits, and accelerated depreciation of the project's capital cost, including infrastructure required to transport and inject carbon dioxide.
2. Royalty rates—we suggest that the government consider providing declining royalty rates on federal leases where CO_2 EOR is used.
3. Legal issues—legal areas that warrant clarification include: 1) confirming subsurface pore-space as part of the mineral estate, 2) predictable and defined rights and obligations relating to subsurface pore-space ownership, 3) the ability to easily modify historic field unit agreements to accommodate EOR operations, including potential unitization issues raised by the sequestration of CO_2, and 4) clear expectations regarding the disposition and abandonment of EOR wells and fields, including oilfield carbon dioxide sequestration sites. However, we believe the current regulatory provisions and permitting regimes for conventional CO_2 EOR operations work very well and provide thorough oversight by the regulators and opportunity for public input.

In addition to these recommendations, I now want to discuss the role that CO_2 EOR technology can play in controlling greenhouse gas emissions. In particular, one of the benefits of injecting carbon dioxide for enhanced oil recovery is the ability to store significant volumes of carbon dioxide in the reservoir both during and after oil and gas production. In typical EOR operations, approximately one third to one-half of the carbon dioxide initially injected becomes trapped in the reservoir. The rest is recycled from oil producing wells as a valuable commodity and reinjected. CO_2 is not vented to the atmosphere. Additional trapping of carbon dioxide occurs with each subsequent injection cycle so that, eventually, nearly all of the initial CO_2 volume becomes stored in the formation and more CO_2 must be procured to maintain oil production rates. As I mentioned earlier, Occidental currently injects approximately 500 billion cubic feet of CO_2 per year. Of this 300 billion cubic feet is recycled CO_2 from producing wells, and the other 200 billion cubic feet—approximately 40% of the injected CO_2—is newly supplied to the floods to make-up for the quantity stored through the CO_2 flooding process. To put this in context, each year the amount of CO_2 that Occidental injects is equivalent to the emissions from ten 150-megawatt coal-fired power plants.

Occidental has 30 plus years of history using naturally occurring carbon dioxide, which we produce from underground reservoirs or buy from other producers as a commodity. However, we could just as easily use carbon dioxide captured from emissions of electric utilities, refineries and other large sources—if it were available at competitive prices in the Permian Basin or at other fields suitable for CO_2 flooding. We believe the key challenges to using man-made carbon dioxide in EOR operations are the cost of the technology to capture carbon dioxide from industrial and power generation sources and the cost of building the infrastructure to transport the carbon dioxide to an injection site and compress it to a higher pressure that allows it to be injected into an oil reservoir for enhanced recovery.

Additional incentives and policies would be useful to expedite building carbon dioxide pipelines and to offset the cost of adding equipment to capture and compress emissions containing carbon dioxide. Also, since natural CO_2 supplies are not available near most oil fields that are amenable to CO_2 flooding, consideration should be given to developing policies and incentives that encourage locating new industrial operations and power generation with large carbon dioxide emissions near such oil and gas reservoirs. The utilization of these man-made CO_2 sources would enable more widespread application of CO_2 EOR to increase domestic oil supplies.

Many organizations are now looking at the underground storage of carbon dioxide, which is also known as geological storage or sequestration, as an approach to controlling greenhouse gas emissions. Occidental sees mutual benefit from the use of carbon dioxide for enhanced oil recovery and the storage of carbon dioxide as a way to control greenhouse gas emissions. The 2005 special report sponsored by the Intergovernmental Panel on Climate Change on carbon dioxide capture and storage strongly endorsed the idea and said that EOR technology can provide a substantial technical head start on proving the concept of geologic storage of carbon dioxide at commercial scale. Occidental concurs.

Occidental also believes that industry experience using CO_2 for enhanced oil recovery provides technical information and demonstrated results for long-term CO_2 sequestration. In fact, this technology we are using is the gateway to future large scale carbon sequestration operations. The industry's 30-year history of using CO_2 for EOR provides evidence that CO_2 can be managed safely and should allay con-

cerns about long-term storage of CO_2 in oil and gas reservoirs as well as other geologic formations.

Occidental believes that, while storing man-made carbon dioxide in oil and gas reservoirs and other underground formations is not the only option for reducing greenhouse gas emissions, it is an important, commercially viable option that can be rapidly implemented to accomplish this objective, particularly because it carries with it the substantial additional benefit of increasing domestic oil and gas production.

Thank you for the opportunity to speak today and share Occidental's experience using carbon dioxide to enhance and increase oil and gas production in the United States, as well as our ideas for creating policies and incentives to increase its use and expedite development of a national infrastructure to capture, transport, inject, recycle and store underground carbon dioxide that has traditionally been emitted to the atmosphere.

Response to questions submitted for the record by William Roby, Vice President—Worldwide Engineering and Technical Services, Occidental Oil & Gas Corporation

1. Question: Mr. Roby, there are a lot of questions with regard to carbon sequestration. What has the safety record been like in your operations? And do you have any problems with pipeline leaks?

Response: The safety and environmental record at our CO_2-EOR operations has been consistently good. As I indicated in my testimony our operations have been in existence for approximately 30 years and Occidental acquired the assets in 2000. During the time of our operation we have had no safety problems related to the use of CO_2 or its transportation. With regard to pipeline leakage, we have typical oil and gas pipelines in the fields in addition to the necessary CO_2 pipelines. Our pipeline system is subject to the normal maintenance issues associated with such systems but we have had no safety problems with the handling or transportation of CO_2. Because the CO_2 pipelines do not carry volatile substances, they pose much less of a safety and environmental risk than typical oil and gas pipelines.

2. Question: Mr. Roby, what federal and state EOR incentives is your company taking advantage of?

Response: Section 43 of the Internal Revenue Code has a provision for Enhanced Oil Recovery Credit which allows a 15% credit on the cost of CO_2 (including the transportation to the site) for qualified enhanced oil recovery projects where first injection commenced after 1990. If a company takes the credit, it then loses the deduction for the cost so it nets out to approximately a 10% credit. We were able to take advantage of this provision for several years, however, the credit phased out when the cost of oil went above the inflation-adjusted cap (now approximately $46 per barrel) in 2005. Therefore, we have not been able to use this credit since 2005.

Occidental is actively performing CO_2-EOR only in the states of Texas and New Mexico and each state treats EOR projects differently from a tax standpoint. In New Mexico, EOR incentives are available to producers only under certain circumstances. Qualifying projects can get relief of 50% of the state severance tax rate, which is 3.75%, so the net benefit to a producer would be 1.875%. However, this incentive phases out when the price of oil goes above $28 per barrel, which it did in 2003. Our North Hobbs Unit began production after 2003 and consequently, we have not received any state incentives for our New Mexico EOR operations.

In Texas, incentives are also allowed in certain circumstances. Producers may take advantage of a 50% oil severance tax reduction on EOR projects approved by the state. The severance tax rate is 4.6% so the net tax reduction is 2.3% of the market value of oil produced using CO_2 injection. Occidental is currently taking advantage of this tax provision in Texas.

3. Question: Mr. Roby, how much natural gas is produced during CO_2-*EOR operations and what happens to it?*

Response: While the primary target of our CO_2-EOR is oil, in some cases, we do encounter "associated" natural gas. The amount of natural gas produced varies from field to field and from well to well and is not easy to quantify in the abstract. Generally, the natural gas is captured and sent to a processing plant where the CO_2 and other compounds are removed; then the natural gas is put into a pipeline and sold. In our operations, we use the recovered CO_2 again in EOR operations.

4. Question: Mr. Roby, what sort of production levels could we see from CO_2-*EOR over the next 10 to 20 years? Could we reach 1 million barrels a day? What would it take to make those sorts of production levels a reality?*

Response: Currently, the U.S. produces about 200,000 barrels of oil per day (BOPD) using CO_2-EOR with about 180,000 of those barrels being produced in the Permian Basin of Texas and New Mexico. As I indicated in my testimony, fields respond differently to CO_2-EOR and some fields are simply not responsive to CO_2 or geologically amenable to the application of CO_2-EOR technology. In order to substantially increase the recovery of oil using CO_2-EOR, it will be necessary to ascertain whether a particular field is amenable to CO_2-EOR, find sources of CO_2 and then build the infrastructure to get the CO_2 to the fields. Ultimate production levels will, of course, depend upon the costs of each project and the price of oil. It is certainly possible that production could reach 1mm barrels per day given adequate CO_2 and investment in infrastructure; however, this level of production is unlikely in the foreseeable future absent some governmental incentives. Using the current U.S. production as an analog, our industry has grown production 200,000 BOPD over the past 20 years. This suggests that CO_2 induced production could be in the 300,000 to 400,000 BOPD range over the next 10-20 years unless unusual investment incentives are undertaken.

Mr. COSTA. I want to be fair to all the witnesses in terms of the timing, and you exceeded your time. But we do appreciate your testimony.

Our next witness is Mr. Greg Kunkel. You are Vice President of Environmental Affairs in Tenaska, Inc., is that correct?

Mr. KUNKEL. That is correct.

Mr. COSTA. Wonderful. Please begin your testimony.

STATEMENT OF GREG KUNKEL, VICE PRESIDENT, ENVIRONMENTAL AFFAIRS, TENASKA, INC.

Mr. KUNKEL. Thank you, Chairman Costa, Ranking Member Pearce, and members of the Subcommittee.

My name is Dr. Greg Kunkel, Vice President of Environmental Affairs at Tenaska. And I am pleased to be here to share our views on enhanced oil recovery.

Tenaska is one of the nation's top developers of large, efficient power-generation facilities. In fact, the Natural Resource Defense Council ranks Tenaska as having the lowest carbon footprint of any of our peers, with less than half of the national average emission rate of greenhouse gases.

Tenaska's record demonstrates that significant greenhouse gas emission reductions can be accomplished in the power sector using low-carbon fuels, like natural gas, and advanced combined-cycle technology.

Today, however, I am here to talk about achieving even more, and not with natural gas, but with coal, with the help of the oil industry, and potentially with your help.

Over the last several years, high and volatile natural gas prices have stimulated a growing demand for baseload electric generation resources, like coal and nuclear, with lower and less volatile fuel costs, and 24-hour-per-day operation.

Because market conditions were obvious to everyone, many coal-fired facilities were proposed, and many advanced to some stage of development. Some have been, or are being, built, but many more have been postponed or canceled due to uncertainty about future legislative caps on greenhouse gas emissions, among other things.

Tenaska has concluded that baseload generation using coal is still very necessary to avoid soaring electricity prices in the future. But the control of greenhouse gas emissions in the most cost-effective manner should be a part of any future coal development.

We believe that enhanced oil recovery has an important role to play in achieving cost-effective emission control for early adopters of carbon emission control technology.

Currently, Tenaska has an early development of commercial-scale coal-fired baseload power facilities that is unlike any currently in operation. Tenaska's objection has been to find ways to develop the baseload resources that the market for electricity requires.

In enhanced oil recovery, we see a way to do that and provide carbon dioxide as a commodity in an existing market, in which the end use also accomplishes geologic storage.

The Tenaska Trailblazer Energy Center, located near Sweetwater, Texas, in the Permian Basin, where the best EOR opportunities exist, is designed to capture up to 90 percent of its potential carbon dioxide emissions, and deliver that CO_2 via pipeline for use in enhanced oil recovery. Trailblazer will utilize super-critical pulverized coal technology, and we are considering adding carbon dioxide-capture technologies, among others.

While Tenaska is fully focused on developing Trailblazer, and it could be in operation as early as 2014, it is important to recognize that we have developed this project in anticipation of Federal climate change legislation that offset the significant capital and operating costs of carbon-capture technology.

Without a carbon regulatory regime to ensure that avoidance of greenhouse gas emissions has a monetary value, it appears that revenues from enhanced oil recovery carbon dioxide sales will be insufficient to cover all carbon-capture costs. However, if carbon emissions are regulated, projected compliance cost savings and other regulatory effects, combined with EOR revenues, would provide the needed economic incentives to build Trailblazer.

Perhaps the most important thing Congress could do to facilitate the development of Trailblazer or other similar CCS projects is to provide industry with regulatory certainty, particularly a regulatory framework within which a market can develop that values greenhouse gas emission reductions.

In the past, Congress has employed a number of effective policies to help overcome barriers to entry and encourage new energy technologies. Tenaska generally supports those mechanisms that provide the greatest degree of certainty; we do a lot of financing. We prefer investment tax credits and accelerated depreciation to Federal grants or loan guarantees, primarily because of predictability.

Should the House decide to pursue a cap-and-trade mechanism, some of the potential areas where the specifics of climate change legislation could affect the project are allowance allocations, use of auction proceeds, mobilization of equipment manufacturers and others in the industry, necessary regulation, and electricity pricing.

In summary, proven technology is available today to capture greenhouse gases from coal-fired power plants, and the value of carbon dioxide-enhanced oil recovery makes that technology cost-effective if we also value a reduction in greenhouse gas emissions.

As previously acknowledged, Trailblazer was conceived and has been designed in anticipation of Federal climate change legislation. In the absence of such legislation, Trailblazer faces costs and risks that likely cannot be offset by revenues from EOR.

For the benefit of demonstrating carbon capture and storage at commercial scale, Congress may elect to support a few carbon-capture projects, and we would hope that cost-effective projects associated with EOR will be given some consideration in that event.

Thank you again for your interest in this subject. I would be pleased to respond to any questions at the right time.

[The prepared statement of Mr. Kunkel follows:]

Statement of Gregory P. Kunkel, Ph.D., Vice President of Environmental Affairs, Tenaska, Inc.

Thank you Chairman Costa, Ranking Member Pearce and Members of the Subcommittee.

My name is Dr. Greg Kunkel. I am Vice President of Environmental Affairs for Tenaska, Inc., and I am pleased to be here to share our views on opportunities for enhanced oil recovery using carbon dioxide captured from a power plant. I believe Tenaska can provide important insight to Congress on this matter because of an electric generation project Tenaska has in early development: a commercial-scale, coal-fired, baseload power facility that, unlike any currently in operation anywhere, would capture up to 90 percent of its potential carbon dioxide (CO_2) emissions and deliver that CO_2 for use in enhanced oil recovery operations and geologic storage.

Tenaska is a privately held company that builds, owns and operates power plants, among other business activities detailed at the end of this testimony. Congress and developers of power plants share some common interests concerning climate change legislation. You and I both want to know what it will cost to eliminate greenhouse gas emissions from power generation through carbon capture and storage technologies. If the answer to this was well known, then climate change legislation could be crafted that would pose less risk to the economy. From the perspective of the electric industry, technological risks for the first commercial carbon capture and storage facility are compounded by the fact that federal greenhouse gas cap-and-trade or other governing regulatory structures do not yet exist, and it is unclear whether state or regional regulatory structures will prevail over the long term. International obligations have not been finalized. Whereas industry looks to Congress for a structured market with rules, Congress reasonably looks to industry for at least a preliminary estimate of the costs.

Academics, policy makers and even the leadership of the G8 countries seem to agree that the country, and the world, needs a number of large-scale carbon capture and storage projects that will resolve critical technical and economic feasibility issues. Tenaska believes that enhanced oil recovery (EOR) can contribute to advancement of such a project by simultaneously providing for geologic storage of CO_2 and a significant economic benefit that could help to pay for early deployment of carbon capture technology. Whatever the costs for carbon capture and storage will be, and I do not have a final answer for you on that, I do know that net costs will be less if we can make economic use of the CO_2. The testimony that follows describes how Tenaska became interested in EOR, the development status of our project, and some thoughts on what Congress can do to advance commercial deployment of baseload generation with carbon capture and storage.

Challenge: Building Baseload Generation in an Uncertain Regulatory Environment

Tenaska is one of the nation's top developers of large, efficient power generation facilities. The Natural Resources Defense Council ranks Tenaska as having the lowest carbon footprint of any of our peers—less than half of the national average emission rate of greenhouse gases. As developers, rather than researchers or inventors, Tenaska's focus is on projects that can be accomplished with available, reliable, cost-competitive equipment and for which development investments can be made with a reasonable assurance of success.

Over the last several years, market conditions for development of generation facilities have included high and volatile natural gas prices, oversupply of natural gas generation capacity in much of the country, financial failures of merchant generators, regional growth in renewable energy resources, and growing demand for "baseload" resources, like coal and nuclear, with lower and less volatile fuel costs and

24-hour-per-day operation. Many coal-fired facilities advanced to some stage of development, some have been or are being built, but many more have been postponed or canceled due to various combinations of escalating costs, environmental opposition, utility owner and commission concerns about long-term investment in coal, and uncertainty about future environmental and climate change-related requirements.

Tenaska's objective has been to find ways to develop the baseload resources that the market for electricity requires. We were reticent to invest in solid fuel projects without addressing the climate change issue, so a question before us was how to reduce greenhouse gas emissions in the design of projects today. To accomplish this, we needed to assure ourselves that carbon capture technologies were ready for a utility-scale project; a secure home was available for captured CO_2; and the economics and long-term financing arrangements for such projects would work.

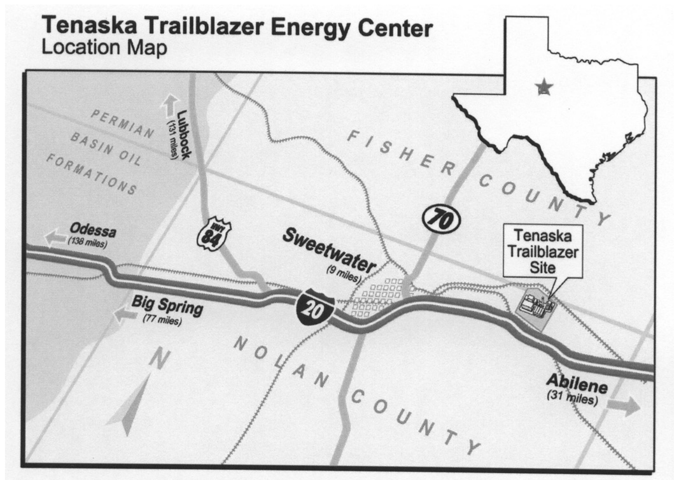
New Coal Plants with Carbon Capture: Enhanced Oil Recovery as a Business Opportunity

In enhanced oil recovery (EOR), Tenaska saw an attractive market for CO_2 in which geologic storage is accomplished under an existing, federal regulatory structure. Interviews with oil producers with EOR expertise suggested a considerable appetite for additional supply. However, the current opportunities to meet this demand are geographically limited, and significant barriers exist to new EOR development. Pipelines for transporting CO_2 are specialized, high-pressure pipelines with relatively high construction costs, so the distance between the source and the injection sites is critically important.

Tenaska embarked on feasibility studies to evaluate whether a coal-fired generation facility with carbon capture capability could be economically developed in or near the Permian Basin, where a robust EOR market exists. We focused on coal sourced from the Powder River Basin that would be delivered by rail. We reviewed greenfield and brownfield pulverized coal as well as integrated gasification combined cycle (IGCC) generation technologies, but ultimately selected supercritical pulverized coal with amine CO_2 capture technology for further work.

Some of the well-known advantages of IGCC technology with respect to CO_2 capture efficiency are to some degree offset by reduced efficiency of combustion turbines at the altitude of West Texas sites. Supercritical pulverized coal technology enjoyed a relative advantage in our analysis with respect to equipment availability, cost certainty, reliability, industry experience, competitive procurement and development costs. Amine-based CO_2 absorber/stripper systems have been in operation on smaller scales and represent the more mature technology available for utility carbon capture applications. Tenaska continues to evaluate alternative technologies, including ammonia-based systems.

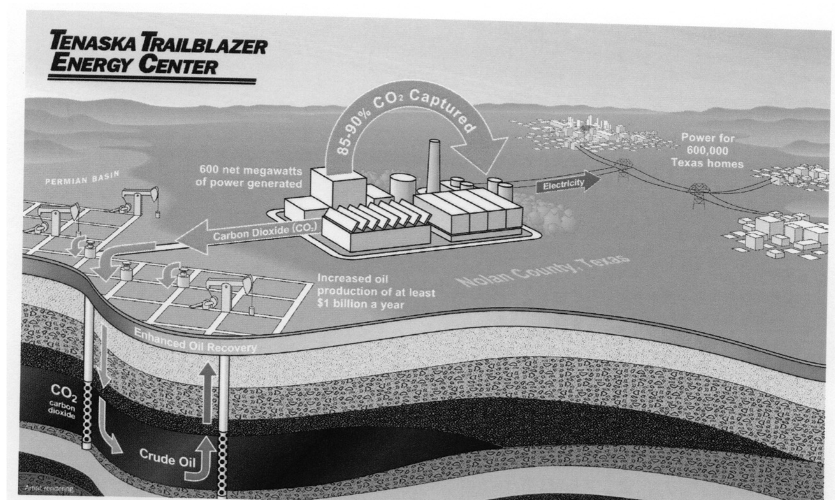
In October, 2007, Tenaska committed funding for engineering, site development, and permitting of a supercritical pulverized coal facility with carbon capture to serve the Electric Reliability Council of Texas (ERCOT) and Permian Basin EOR markets. The ERCOT power market provides good opportunities for a facility of the sort we are proposing. It has a need for baseload power and the ERCOT transmission system is located in suitable proximity to the Permian Basin, where good EOR opportunities exist. In addition, it is a market with which Tenaska is very familiar. We have developed approximately 3,500 MW of generation capacity in ERCOT, and our power marketing group is headquartered there.



The Tenaska Trailblazer Energy Center would be located near Sweetwater, Texas, close to the Permian Basin border.

Tenaska's Trailblazer Energy Center

On February 19, 2008, Tenaska publicly announced the Trailblazer Energy Center, a 765 MW gross output and 600 MW net output supercritical pulverized coal electric generation facility with the capability to capture and deliver to the EOR markets 90 percent of CO_2 produced in the boiler. On the same day, we closed the site property transaction, an air permit application was filed with the Texas Commission on Environmental Quality, and a transmission interconnect request was filed with ERCOT.



The Tenaska Trailblazer Energy Center would be the first electric generating station to capture the carbon dioxide it produces and transport it via pipeline for use in enhanced oil recover and geologic storage.

Tenaska is fully focused on the development of Trailblazer. Our schedule calls for completion of studies to support engineering, procurement and construction contracting as well as issuance of key environmental permits by the first quarter of 2009. Financial closing and initiation of construction may be as early as the fourth quarter of 2009. Construction requires about four and half years, so commercial operation could be as early as 2014. Currently, we are performing technical and economic analyses of competing carbon capture technologies and vendor offerings;

transmission studies are underway; water resource studies are in process; and intensive permitting and site development work is ongoing.

Merits of Trailblazer include the following:

- 600 MW of needed baseload generation capacity to the ERCOT electric transmission grid.
  - Addition of baseload power reduces marginal power prices to the benefit of consumers across the system.
  - Coal-fired capacity helps insulate Texas electric customers against natural gas price volatility.
- Enhanced Oil Recovery and Carbon Sequestration
  - Availability of CO_2 renders a greater fraction of the original oil in place recoverable, thereby adding to recoverable reserves.
  - Actual production of oil is increased. If the historical Permian Basin EOR response is used as a guide, this could mean more than 34,000 incremental barrels of oil per day associated with Trailblazer's 300 million cubic feet per day of CO_2.
  - Recapture and re-injection of CO_2 produced with the oil can provide a high percentage of permanent geologic storage of the gas.
- Economic Impact
  - Provide 1,500 to 2,000 jobs over a lengthy construction period.
  - Create more than 100 permanent and well-paying jobs.
  - Stimulate the local economy with construction spending over $2 billion and a total project cost over $3 billion
  - Enable $1 billion incremental Permian Basin oil production annually.
  - Reduce the rate of decline of U.S. production and dependence on imported oil.
- Environment
  - Post-combustion capture, if successfully demonstrated on this scale, could have a wider application. Indeed, our investigation indicates that retrofitting existing coal stations with CO_2 capture technology may have about the same cost as the addition of this equipment to a new facility. According to the Intergovernmental Panel on Climate Change (IPCC), there are about 5,000 large power plants worldwide with combined emissions of over 10 billion tons of CO_2 per year.
  - Higher levels of sulfur dioxide (SO2) removal will likely be needed, pushing criteria pollutant emissions control to a new level.
  - An opportunity is presented for recapture of flue gas water that may enable gains in water use efficiency.
  - Trailblazer may also utilize air cooling or hybrid cooling systems that further decrease water requirements.
  - Expanded production of oil from existing fields has less impact than development of new fields.

Commercial Challenges Facing Trailblazer

For Trailblazer to become a commercial enterprise, there are significant challenges to overcome. Many of the more substantive challenges relate directly to the carbon capture and storage component. The costs of carbon capture using existing technology scaled to utility-sized application are daunting. The capital investment in carbon capture could add as much as a $1 billion to a $2 billion power plant, when financing and other "soft" or indirect costs are included. There are ongoing operating costs as well. At Trailblazer, the equivalent of 200 MWs of electricity and steam may be consumed in the CO_2 capture and compression process that otherwise would be delivered to the ERCOT power grid.

There are other, less direct "early-adopter" costs associated with introducing new technology that will affect Trailblazer. New technologies carry inherent risk. Until the first commercial plant is built and operated, and the risks have been quantified, each participant in the development, construction, and financing process will place a risk premium on their participation to cover unknown but real contingencies. Once there is a suitable track record for commercial utility-scale carbon capture technology, associated risks can be assumed by those most capable of mitigating them and the risk premium will be reduced.

Since announcing Trailblazer in February, my colleagues and I have been busy explaining the project to local and regional stakeholders and policymakers and also to staff and Members of Congress here in Washington. The response has been generally very supportive, even among groups and individuals long opposed to new additions of coal-fired generation capacity. To maintain that support, we recognize that continued engagement will be needed throughout the development process, and we have much yet to do.

Impact of Federal Polices on Trailblazer

Perhaps the most important thing Congress could do to facilitate the development of Trailblazer or similar carbon capture and storage projects, is to provide regulatory certainty, and in particular, a regulatory framework within which a market can develop that values greenhouse gas emission reductions. Without regulatory certainty and recognition of the value of emission reductions, developers are confronted with making multibillion dollar decisions in a policy vacuum. No developer can operate effectively while having to speculate on regulatory outcomes, especially outcomes so fundamental to the success of the enterprise.

Accordingly, we have developed Trailblazer in anticipation of federal climate change legislation that would support, through placing a price on greenhouse gas emissions and other means, the significant capital and operating costs of carbon capture technology. Without climate legislation, it appears that revenues from enhanced oil recovery CO_2 sales will be insufficient to cover all carbon capture costs. With proposed climate legislation, projected compliance cost savings and other effects of climate change legislation, combined with EOR revenues, would provide the needed economic incentives to build and operate Trailblazer.

Some of the potential areas where climate change legislation could affect the project are:

- Allowance allocation. Most cap-and-trade legislative proposals include some free allocation of emission allowances for new sources, and may include bonus allowances for generation units with carbon capture and storage.
- Auction proceeds. Cap-and-trade proposals may produce governmental revenue by auctioning greenhouse gas emission allowances to regulated entities. Auction proceeds may be directed to construction of early carbon capture and storage projects or performance payments for demonstrated sequestration.
- Industry mobilization. Utility equipment manufacturers, financial institutions and service providers would be encouraged to bring forward competitive new offerings to address the risks and opportunities of a large new market. To some degree, this is occurring in advance of legislation, but is clearly a result of the industry's sense that climate change legislation is inevitable within the next couple of years. An interesting byproduct of our investigation of capture technologies is that there does not appear to be an insurmountable cost penalty for retrofit applications. This implies a potential to apply similar technology to much of the nation's existing fossil fleet.
- Regulatory framework. Climate change legislation will likely provide for further regulatory development to provide for the establishment of greenhouse gas registries, industrial emission monitoring rules, permitting, monitoring and verification of greenhouse gas sequestration sites; and address long term liability for geologic storage sites. Sequestration achieved through EOR needs to be specifically recognized in such regulations. Development of the regulatory framework is critically important.
- Increased electricity price. Almost any kind of climate change legislation will associate a cost with emissions of greenhouse gases such as CO_2. Because of compliance costs of uncontrolled generation facilities, higher market electricity prices can be expected.

In the past, Congress has employed a number of effective policies to help overcome barriers to entry and encourage new energy technologies. We support those mechanisms that provide the greatest degree of certainty with respect to their application and that have clearly established guidelines. We prefer investment tax credits more than federal grants or loan guarantees primarily because the predictability of receiving tax policy benefits is greater and more controllable than the possibility of being awarded a grant or loan guarantee by a federal agency. Such accounting practices as an accelerated depreciation standard applied to the carbon capture component of Trailblazer would facilitate faster recovery of investment capital, and would provide a material incentive that we and our financing counterparties could evaluate with a higher degree of certainty. Absolving early sequestration projects from CO_2 liability would similarly facilitate more enthusiastic participation by the financial community.

Should the House decide to pursue a cap-and-trade mechanism similar to what has been contemplated in the Senate, we would advocate for an economy-wide approach. We would support bonus provisions for early adopters, and for EOR to be eligible for the same level of benefits as other CO_2 sequestration mechanisms. We would prefer that natural gas be regulated upstream from the emission source, to encompass a greater number of emitters while regulating fewer sources, and to avoid cost-recovery issues for entities holding long-term power delivery contracts.

Conclusion

Tenaska confronts many significant challenges in its effort to take the Trailblazer project from concept to reality. Trailblazer has been designed in anticipation of federal climate change legislation. In the absence of such legislation, Trailblazer faces costs and risks that likely cannot be offset by revenues from power generation and marketing CO_2 for enhanced oil recovery. Trailblazer can wait until federal legislation is enacted or Congress can act in other ways to support such a project now.

Thank you again for your interest and for the opportunity to provide some details on this exciting project. I would be pleased to respond to any questions you may have.

About Tenaska

Tenaska is an energy company that develops, constructs and operates non-utility electric generation and cogeneration facilities that it owns in partnership with other companies. The company also markets natural gas, electric power and biofuels and provides energy risk management services. In addition, Tenaska is involved in asset acquisition and management, fuel supply, natural gas transportation systems and electric transmission development. Tenaska was founded in 1987, and is a privately held company with headquarters in Omaha, Nebraska, and regional offices in Texas, Colorado, and Alberta, Canada. The company currently has more than 600 employees; 2007 gross operating revenues were $11.6 billion.

Tenaska has considerable experience as a developer of electric power generation, having built more than 9,000 megawatts of highly efficient, state-of-the-art power generation facilities associated with more than $10 billion in total financial transactions.

Response to questions submitted for the record by Greg Kunkel, Ph.D., Vice President, Environmental Affairs, Tenaska, Inc.

1. Dr. Kunkel, if your project requires a cap-and-trade system to become economic, and you're getting revenues from selling the carbon dioxide for EOR, does that mean that a cap-and-trade system by itself wouldn't get companies to capture carbon dioxide unless there was an enhanced oil recovery option?

Response: EOR should make carbon capture economic sooner than it would be otherwise. Any of the proposed cap-and-trade systems would have the benefit of providing a price signal that companies could use, among other factors, to guide investment decisions related to carbon dioxide capture facilities. Economic analyses of various cap-and-trade proposals suggest that those price signals, particularly the implied operating cost related to emitting each ton of carbon dioxide or other greenhouse gas, would likely be below the level that would justify carbon capture in the early years of cap-and-trade system implementation. As the emissions allowed under the cap are reduced over time, then we expect that emissions allowance pricing would eventually justify carbon capture, based also on our current understanding of carbon capture capital and operating costs. By 2050, when emissions reductions of 50 to 80 percent may be required, it is clear that carbon capture must be and would be widely implemented for generation facilities that utilize fossil fuels.

EOR revenue has the effect of rendering carbon capture economic at the earliest possible date. By effectively making the cost of emissions reductions lower, EOR can reduce the costs of any cap-and-trade program.

In addition to the price signal provided by any cap-and-trade system, auction of emission allowances would also provide revenues that could be directed toward early emission reduction actions, like carbon capture. A cap-and-trade system can also be designed to provide bonus allowances for carbon capture. From Tenaska's perspective, such incentives are most effective when the economic benefit is very clear, such as a defined payment for each ton sequestered, so that any benefit is deemed credible by investors and lenders.

Another important consideration is the general state of capture technology. Current pilot testing and demonstration projects for new technologies and full scale design and construction of the first utility scale projects will reduce uncertainty in our cost estimates, demonstrate the limits of performance of alternative capture technologies, and pave the way for lower cost capture facilities in the future.

2. Dr. Kunkel, what percentage of carbon dioxide do you estimate you will capture at your plant?

Response: Tenaska's ongoing review of carbon capture technologies for post-combustion applications indicates that we will be able to design a facility to achieve 85

to 90 percent capture of carbon dioxide. We intend to capture this percentage from the entire flue gas stream, not just a side stream as proposed in various pilot projects.

I would like to thank the Subcommittee Members and Staff for their interest in Tenaska's Trailblazer Project and the potential for carbon capture from power facilities to support enhanced domestic production of oil.

Mr. COSTA. Thank you, Dr. Kunkel, for your very good testimony.

Our next witness is Dr. Ian Duncan, Associate Director from the Earth and Environmental Systems, Bureau of Economy Geology for the University of Texas at Austin. Is that correct?

Mr. DUNCAN. The Bureau of Economic Geology.

Mr. COSTA. At the University of Texas.

Mr. DUNCAN. At the University of Texas at Austin. Yes, sir.

Mr. COSTA. I understand you have a good school down there.

Mr. DUNCAN. That is the rumor.

Mr. COSTA. We are glad to have you here. Please begin your testimony.

STATEMENT OF IAN DUNCAN, ASSOCIATE DIRECTOR, EARTH AND ENVIRONMENTAL SYSTEMS, BUREAU OF ECONOMIC GEOLOGY, THE UNIVERSITY OF TEXAS AT AUSTIN

Mr. DUNCAN. I appreciate the opportunity to testify. I would first say that the Chairman has stolen most of my thunder and made most of my points, but I will try to add a few things to his remarks.

Mr. COSTA. Good points are always worth underlining, especially when you agree with the Chairman.

Mr. DUNCAN. CO_2-enhanced oil recovery can impact atmospheric CO_2 levels in a significant way. Currently, in the Permian Basin on Texas, 30 million tons a year of CO_2 are being injected into depleted oilfields. Approximately 15 percent of this is coming from industrial sources currently. I believe that 99 percent, give or take half a percent, of that CO_2 actually ends up in long-term storage in the subsurface.

We have over 35 years of history of CO_2 injection in the Permian Basin. And this really makes this a real interesting laboratory to look at the effects of CO_2 in the subsurface. Several people have mentioned leakage. Our biggest hope for understanding leakage is to look at these longstanding floods in the Permian Basin. And it is unfortunate that, apart from the small project that the Bureau has running, there is very little study of this at the moment.

Government can encourage early entry capture projects. As Tracy Evans said, this is going to be critical to get CO_2-enhanced oil recovery going based on anthropogenic CO_2. In fact, what we need to do is transition from business-as-usual CO_2 EOR to what I would call next-generation CO_2 EOR.

Business as usual is mostly using natural CO_2 uses technologies that minimize CO_2 usage for historical reasons, has limited monitoring, and mostly takes place in 80 percent of the Permian Basin of Texas, and results in about 15 percent, give or take, additional oil recovery.

Next-generation enhanced oil recovery could be based mostly on anthropogenic CO_2, if we can get the capture, should maximize CO_2 usage using new technologies, some of which are on the horizon, but need further research; we will have sequestration-grade moni-

toring, or MMV; we will have higher-percentage oil recoveries, and will spread out across the country to multiple states in multiple sedimentary basins.

CO_2-enhanced oil recovery can play a major role in paying for the infrastructure that can be later used for sequestration on a large scale in brine reservoirs.

We at the Bureau have estimated that 3.8 billion barrels of oil are available outside the Permian Basin in Texas that could be gained through CO_2-enhanced oil recovery. We also need more trained personnel if we are going to ramp up. We need more graduate student research, more DOE grant funding, to train the personnel that we need to do this.

A lot of the people in this industry are my age, and are going to be retiring over the next five to 10 years. Personnel is a major issue. I think we also need an aggressive research program to help increase oil recovery as this next generation approaches, and lower risk.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Duncan follows:]

Statement of Ian Duncan, PhD, Associate Director, Bureau of Economic Geology, University of Texas at Austin

My name is Ian Duncan. I have a PhD in Geological Sciences and I am an Associate Director of the Bureau of Economic Geology (BEG) at the University of Texas at Austin. The BEG is engaged in a wide range of applied research in a broad range of energy related and environmental issues including CO_2 sequestration. The BEG's Gulf Coast Science Center (GCCC) part of my group is an industry-academic collaboration that has been working on geologic CO_2 storage including CO_2 EOR since 1988. The GCCC currently has significant field tests underway, one Scurry County Texas (Kinder Morgan's SACROC CO_2-EOR field) and two in Mississippi (Denbury resources Cranfield CO_2-EOR sit). These field tests seek to how effectively CO_2 injected for EOR is retained in the subsurface, and how we can best predict and document this retention through modeling and monitoring. These studies are funded by about $50 million in Department of Energy funds (over 10 years). For the past nearly four years I have been doing research on the role that CO_2 Enhanced Oil Recovery (CO_2-EOR) can play in mitigating greenhouse gases in the atmosphere and in increasing domestic oil production in the US.

The key points that I would like to make are:

(1) In the near term CO_2-EOR can make a significant contribution to mitigating increases in CO_2 emissions into the atmosphere by putting significant quantities of anthropogenic or man-made CO_2 (CO_2-A) into permanent storage in depleted oil reservoirs

(2) Government should encourage "early-entry" capture at power plants and other industrial sources of CO_2 emissions to supply CO_2-A for CO_2-EOR projects in conjunction with sequestration. It is critical that these projects be allowed qualify for whatever carbon credits or offsets arise out of federal legislation.

(3) Government should provide a policy/regulatory environment that encourages CO_2 EOR operators to change business as usual by: a) utilizing CO_2-A when made available at a reasonable cost from capture at power plants and other industrial sources; b) creating and implementing monitoring, verification and mitigation (MMV) plans to provide assurance of permanent sequestration; and c) conduct life cycle analyses of their projects to measure CO_2 avoided.

(4) CO_2-EOR can provide the financial capacity and rationale for developing a CO_2 capture, compression and transportation infrastructure across a significant portion of the U.S. that can later be used for large scale CO_2 sequestration in deep brine reservoirs.

(5) In the Texas Gulf Coast alone, BEG staff have estimated that an additional 3.8 billion barrels of oil recovery could be achieved through CO_2-EOR. This is almost twice the entire annual domestic oil production of the U.S. at this time.

(6) Industry and University experience related to CO_2-EOR in the U.S. has provided most of the knowledge, expertise and human capacity that will enable CO_2 sequestration to be implemented. Creating funding for CO_2-EOR related

research in the Department of Energy's budget could have a significant positive effect on knowledge creation, technological innovation and technology transfer related to CO_2 sequestration. Such funding would also help produce young engineers and geologists trained in CO_2 injection related technologies and help alleviate a shortage that is critical now and will grow more so in the near future.

(7) An aggressive research program including pilot projects would help improve the performance of current EOR activity and enable the development of new more effective approaches that could increase oil recovery, reduce the geological and technical risks, and enhance sequestration rates incidental to CO_2-EOR.

CO_2 sequestration will involve the capture anthropogenic CO_2 (typically from electric power plants) followed by deep subsurface injection into oil and gas reservoirs, deep unmineable coal beds or deep brine reservoirs. Approximately 80% of the CO_2 injection in the world takes place in the Permian Basin of Texas and New Mexico, making the region the largest commercial market for CO_2. Texas corporations and technical workers have a unique experience base and outstanding safety record, in pipeline transport and subsurface injection of CO_2. Since the early 1970s, CO_2 has been injected into many Permian Basin oil reservoirs to enhance production. Injected CO_2 is dominantly produced from natural accumulations and pipelined to the Permian Basin. In addition, on the order of 10% is now derived from other sources such as gas processing plants where the CO_2 would otherwise have been released to the atmosphere. Currently roughly 30 million metric tons (MMt) of CO_2 are injected annually in the Permian Basin in operations that are closed-cycle. In other words, CO_2 that is produced from the oil reservoirs in association with the recovered oil is recycled (re-injected into the reservoir for additional recovery).

Many individual operations in the Permian Basin are at the scale of CO_2 production associated with coal burning power plants. CO_2-flooding for enhanced oil recovery (EOR) has been active at SACROC in Scurry County since 1972. Kinder Morgan the current operators at SACROC currently inject ~13.5 MMt CO_2/yr and withdraw/recycle ~7 MMt CO_2/yr, for a net storage of ~6.5 MMt CO_2/yr. For comparison, a 500 MW pulverized coal power plant produces roughly 3-4 MMt CO_2/yr. This magnitude of annual CO_2 storage at SACROC is over six times the rate of Statoil's Sleipner project offshore Norway.

The Gulf Coast has a large potential for CO_2 enhanced oil recovery (EOR) outside of the traditional area of CO_2 EOR in the Permian Basin. Using the miscibility screening criteria BEG staff have inventoried 767 oil reservoirs where miscible CO_2 EOR could be applied for an additional 3.8 billion barrels of oil recovery. By way of comparison, annual oil production in USA is about 1.86 billion barrels. This incremental production target is attractive because of value in terms of wellhead value, tax revenue, and economic activity. This EOR activity would lead to the use of large amounts of CO_2, however, it is small in the context of the projected 55 to 70 billion tons of CO_2 emissions for the Gulf Coast over the next 50 years. Deep brine reservoirs in the Gulf Coast have been estimated by BEG staff to have a sequestration capacity about 4 times this value (that is over 200 billion tons of CO_2).

EOR results in storage of CO_2 dissolved in residual oil, dissolved in brine, and trapped as an immobile supercritical phase. Experience in Permian basin EOR projects is that 30 to over 60% of the injected CO_2 is retained in the reservoir during the first pass through the reservoir. Ultimately through recycling 99.. However, the volume retained as a by-product of EOR is small relative to total point source emissions. The large synergy between EOR and reducing carbon emissions is that EOR would enable the construction of an infrastructure linking sources to reservoirs. Very large volumes of brine reservoirs can then be accessed beneath oil production, a concept that we describe as stacked storage. Existence of an infrastructure would reduce the cost of storage of Gulf Coast power plant, refinery, and chemical plant emissions for the next 50 years or more.

The Gulf Coast of the USA is a region of high CO_2 emissions that overlie thick, extensive, and well known subsurface geologic formations. Path forward toward developing an economically viable system for capture and storage include: (1) development of a climate favoring construction of gasifiers using coal, lignite, petcoke and/or biomass as sources (IGCC electric power plants for example), (2) construction of a pipeline backbone to transport CO_2 regionally, (3) a market for CO_2 for EOR in areas beyond the traditional area of use in the Permian Basin, and (4) development of stacked storage, using deeper brine-bearing formations beneath hydrocarbon reservoirs.

Sequestration credits may play a significant role in future CO_2 EOR based on anthropogenic CO_2. The criteria to qualify projects for CO_2 credits are likely to evolve as the industry matures. A recent Texas law creating a tax credit for CO_2 EOR

using anthropogenic CO_2 requires projects to establish a reasonable expectation that they can meet a performance standard of 99% retention for 1,000 years. To meet this standard, operators will likely have to: characterize the seal for their reservoir and demonstrate that it is compatible with this standard; design and implement an appropriate monitoring program and complete a CO_2 life cycle analysis to verify the amount of CO_2 avoided.

Up until now, CO_2 purchase has been the largest cost component of a CO_2-EOR flood. As a result engineers and geologists in companies and the Universities have developed and refined technologies and approaches to minimize CO_2 usage in CO_2-EOR projects. We may be entering a new regime in which CO_2 injection gains credits that changes the fundamental economics. Under these circumstances new or previously little used approaches to CO_2 EOR projects such as vertical floods and CO_2 alternating with CO_2 foam may become viable. Such approaches offer great opportunities for increasing the total oil recovery and maximizing CO_2 storage. However research in combination with full scale field test are almost certainly necessary to convince companies of the viability of these and other "game changing" technologies.

Although this testimony has focused on the Gulf Coast and Permian basin of Texas, significant CO_2-EOR potential also exists in a number of other states including Louisiana, New Mexico, Oklahoma, Wyoming, Illinois, Michigan, California, Kansas, Mississippi, North Dakota and others. In the context of economic growth, global oil demand and atmospheric mitigation of CO_2, a "first step" mechanism is required to sequester large volumes of CO_2 in a manner that later allows pure CO_2 storage to initially "piggyback" via the commercial leverage of the oil recovered.

In summary I would leave you with the following points:

- CO_2-EOR can play a key role in developing the infrastructure and the technical understanding to enable large scale CO_2 sequestration in brine reservoirs.
- CO_2-EOR combined with carbon capture from power plants and other stationary sources can have a significant positive impact on domestic oil production.

Mr. COSTA. Thank you, Professor Duncan. And I look forward to getting back to you with some questions.

Our last witness with this panel is Mr. Mark Demchuk, is that right? Demchuk?

Mr. DEMCHUK. Yes, it is.

Mr. COSTA. And you are the Team Leader with Weyburn of EnCana Oil and Gas Partnership.

Mr. DEMCHUK. Yes.

Mr. COSTA. Did I get that all right?

Mr. DEMCHUK. It is pretty close. Thank you, Mr. Chairman.

Mr. COSTA. You may begin your testimony.

STATEMENT OF MARK DEMCHUK, TEAM LEAD, WEYBURN, ENCANA OIL AND GAS PARTNERSHIP

Mr. DEMCHUK. My name is Mark Demchuk, and as you said, I am EnCana Corporation's Team Lead for our Weyburn CO_2-enhanced oil recovery project.

EnCana is a North American industry leader in unconventional natural gas and integrated oil development. We have significant operations in the United States, including two refineries that we have in partnership with Conoco Phillips, one in Illinois and one in Texas.

In 2007 our U.S. natural gas production from operations in Wyoming, Colorado, and Texas totaled 1.3 billion cubic feet per day. The Weyburn project is located in Saskatchewan, Canada, and is a technology-driven business that is both Canada's largest carbon dioxide-enhanced oil recovery project, as well as the world's largest CO_2 geological storage project.

I am currently responsible for all aspects of the Weyburn business, including strategy, business development, technology, drilling, operations, and stakeholder relations.

Last year at a hearing here in May, one of my colleagues from EnCana also testified on the Weyburn project in front of the Subcommittee on Energy and Mineral Resources, and the Subcommittee on National Parks, Forests, and Public Lands. The hearing was titled "Geological and Terrestrial Sequestration of CO_2." So my testimony here today is very similar to what she provided last year.

The geological storage of CO_2 in oil zones offers a novel win-win approach to mitigating emissions, while enhancing production for mature oilfields. In Weyburn, CO_2 has been injected one mile underground for the primary purpose of enhanced oil recovery since 2000, making valuable use of a byproduct that would have otherwise been emitted to the atmosphere from Dakota Gasification Company's coal gasification facility located in Beulah, North Dakota.

Discovered 50 years ago, we now expect the economic producing life of the Weyburn oilfield to be extended up to an additional 30 years, through the use of CO_2-enhanced oil recovery. We currently produce over 28,000 barrels per day, and the field is projected to store around 30 million metric tons of CO_2 over the life of the project. This equates to taking about 6.7 million cars off the road for one year.

At present, we inject about 125 million cubic feet a day of CO_2 from Dakota Gas, and that has resulted in over 10 million tons of CO_2 storage since the project started in 2000.

The Weyburn oilfield has also served as the highly coveted commercial-scale laboratory for the International Energy Agency's Greenhouse Gas Weyburn-Midale CO_2 Monitoring and Storage Project. The first phase of this multi-party international research project, run under the auspices of the IEA, concluded in 2004 that storage of CO_2 in an oilfield is viable and safe over the long term.

Through extensive geological, geophysical, and hydrogeological work, as well as computer modeling, it concluded that after 5,000 years, 99.8 percent of the CO_2 injected into the Weyburn field would remain trapped underground.

Mr. Chairman, EnCana is proud of the Weyburn project. The project did not happen overnight. It took years of technical analysis, substantial capital investment, a viable CO_2 supply, as well as lengthy, complicated negotiations with our partners, CO_2 supplier, and governments. We believe that there are opportunities to conduct similar enhanced oil recovery and storage projects in other areas, and that deep geologic formations can be successfully used to store CO_2.

I must caution, however, that any project must be closely monitored, and there must be a sound scientific basis established to assure that the geologic formation being used is adequate to store CO_2. That is why we continue to work closely with governments, researchers, and industry on the final phase of the IEA project to enable transfer of knowledge and technology gained in Weyburn to a more widespread industrial implementation.

The IEA project is providing a good foundation for development of solid policy, regulations, and operating practices for future CO_2 storage.

I thank you for allowing me to come and testify today, and I would be glad to answer any questions you may have.

[The prepared statement of Mr. Demchuk follows:]

Statement of Mark Demchuk, Team Lead Weyburn, EnCana Corporation, Calgary, Alberta, Canada

My name is Mark Demchuk. I am Team Lead of the Weyburn Unit for EnCana Corporation. EnCana is a dynamic North American leader in the production of oil and gas. I am currently responsible for all aspects of the Weyburn Operation managing a staff of over 100 employees and contractors split between our Weyburn field site and in the Calgary head office.

I am here today at the invitation of the Chairman to discuss EnCana's experience with carbon dioxide(CO_2) enhanced oil recovery and the International Energy Agency's world-class research project at Weyburn centered on the geological storage of CO_2.

Introduction

The Weyburn oilfield, operated by EnCana, is demonstrating that oil production can be increased in an environmentally responsible manner through underground injection of CO_2. CO_2 has been injected into this oilfield since 2000, making valuable use of a by-product that would have otherwise been emitted from Dakota Gasification Company's (DGC) coal gasification facility located in the northern United States. The field is projected to store 30 million tonnes of CO_2 over the EOR life, equal to taking about 6.7 million cars off the road for one year. I will discuss in more depth how EOR is prolonging the life of the Weyburn oilfield, while at the same time contributing to reducing CO_2 emissions.

The Weyburn oilfield has also served as the highly coveted, commercial-scale laboratory for the International Energy Agency (IEA) Green House Gas Weyburn-Midale CO_2 Monitoring and Storage Project. This multi-party, international research project, run under the auspices of the IEA, is investigating the viability of long term storage of CO_2 in an oil reservoir and will provide a good foundation for the development of solid policy, regulations and operating practices for future CO_2 storage associated with EOR. The results of the first phase of the IEA project will be covered as well as the key elements of the final phase, which was launched in 2007.

EnCana Corporation—An Overview

Headquartered in Calgary, Alberta, Canada, EnCana is a leading oil and gas producer in North America, where the company's primary focus is on the development of resource plays. EnCana's portfolio of long-life resource plays includes four key resource plays in the U.S. that produce natural gas. In Canada, five key resource plays produce natural gas and five focus on oil, one of which is the Weyburn property.

In 2007, EnCana produced 3.6 billion cubic feet of natural gas per day from approximately 45,000 wells across North America, in addition to more than 134,000 barrels of oil and natural gas liquids per day. EnCana's U.S. natural gas production averaged 1.3 billion cubic feet per day in 2007.

On May 11, 2008, EnCana Corporation's Board of Directors unanimously approved a proposal to split EnCana into two highly focused energy companies—one a natural gas company with an outstanding portfolio of early life, North American, natural gas resource plays and the other a fully integrated oil company with industry-leading in-situ oilsands properties and top-performing refineries, as well as an underlying foundation of reliable oil and gas resource plays. This transaction, which is expected to be completed in early 2009, is designed to create two highly sustainable, independent entities, each with an ability to pursue and achieve greater success by employing operational strategies best suited to its unique assets and business plans.

EnCana strives to increase the net asset value of the company for shareholders, make efficient use of resources and minimize its environmental footprint. The company's success is determined not only through its bottom line but also through its behaviour. Weyburn is an example of that commitment

Weyburn Oilfield—Enhanced Oil Recovery

Located in the southeast corner of the province of Saskatchewan in Western Canada, Weyburn is a 180-square-kilometer (70-square-mile) oil field discovered in 1954. It is part of the large Williston sedimentary basin, which straddles Canada and the U.S. Production is 25- to 34-degree API medium gravity sour crude. The reservoir is a Mississippian-aged Midale Marly zone, a low permeability chalky dolomite overlying the Midale Vuggy zone, a highly fractured and permeable limestone.

Water-flooding to increase oil recovery was initiated in 1964 and significant field development, including the extensive use of horizontal wells, was begun in 1991. In September 2000, the first phase of a CO_2 enhanced oil recovery scheme was initiated. The EOR project is to be expanded in phases to a total of 92 patterns over the next 15 years. The CO_2 is a purchased byproduct from DGC's synthetic fuel plant in Beulah, North Dakota. If this CO_2 had not been used for EOR and stored, it would continue to have been emitted into the atmosphere. It is transported through a 200 mile pipeline to Weyburn then injected into the reservoir, one mile underground. The CO_2 is 95% pure and Weyburn's current take is 6600 tonnes/day (equivalent to 125 mmscfd).

Discovered 50 years ago, we now expect the economic producing life of the Weyburn oil field to be extended up to an additional 30 years through the use of CO_2 enhanced oil recovery It currently produces over 28,000 bbls/d of light crude oil, the highest production level in 30 years. Without EOR, it is estimated that current production would have declined to 12,000-13,000 bbls/d leaving a huge resource untapped. The environmental benefits are also significant as CO_2 storage contributes to mitigating emissions. The Weyburn project has stored approximately 10 million tonnes of CO_2 to date and over the lifetime of the EOR project, it is projected that an additional 20 million tonnes of CO_2 will be sequestered.

IEA Green House Gas Weyburn CO_2 Monitoring & Storage Project—Phase I

Project description

The IEA Green House Gas Weyburn CO_2 Monitoring & Storage Project is a significant CO_2 monitoring and storage research and development effort that was run in parallel with the commercial Weyburn EOR project during 2000-2004. Phase 1 of this project was designed to contribute significantly to the understanding of greenhouse gas management, specifically the technical feasibility and long term fate/security of CO_2 storage in geological formations.

Initiated in 2000 by the Saskatchewan Ministry of Energy and Mines (now Saskatchewan Industry and Resources), the federal Department of Natural Resources, and PanCanadian Energy Corporation (now EnCana), the first $40 million phase of this multi-disciplinary project has been endorsed by the IEA GHG Research and Development Programme. It was managed by the Petroleum Technology Research Centre (PTRC) of Saskatchewan.

This project constitutes the largest, full-scale, in-the-field scientific study ever conducted in the world involving carbon dioxide storage. Weyburn has become the international flagship project on GHG geological storage research, routinely receiving senior level business and government visitors, as well as media, from around the globe.

The collaborative Phase One research was funded by 15 public and private sector institutions. In addition to the two previously mentioned government departments, other government partners included the United States Department of Energy (US DOE), the European Union, and the province of Alberta through the Alberta Energy Research Institute. Industry sponsors included EnCana, BP plc, ChevronTexaco Corp., DGC, Engineering Advancement Association of Japan, Nexen Inc., SaskPower, TransAlta Corporation and Total SA of France. The project also involved 24 research and consulting organizations in Canada, Europe and the United States.

The overall objective of Phase 1 of the project was to predict and verify the ability of an oil reservoir to securely store and economically contain CO_2. The scope of work focused on understanding the mechanisms of CO_2 distribution and containment within the reservoir into which the CO_2 is injected and the degree to which the CO_2 can be permanently sequestered.

Phase 1 results [1]

Completed in 2004, Phase 1 concluded that CO_2 can be securely stored underground in an oil reservoir such as Weyburn. Through extensive geological, geophysical and hydrogeological work, as well as initially simplistic deterministic and stochastic (probabilistic) performance assessment modeling, the work concluded that after 5000 years, 99.8% of the CO_2 injected into the Weyburn field would remain trapped underground.

A key feature of the project was the pre-injection baseline monitoring that was done prior to CO_2 injection at the field. While there are already commercial applications of CO_2 EOR in the United States, the Weyburn oilfield and the IEA GHG project are unique, due to the comprehensive knowledge of pre-injection reservoir conditions as a result of an extensive historical database of geological and engineering information. This has proven critical to following the movement of CO_2 in the Weyburn reservoir over the four years of the Phase 1 project and to the present day.

Excellent monitoring techniques were demonstrated through the project; the movement of the CO_2 was predicted, monitored and verified by a variety of different methods. The greatest success was encountered with four-dimensional time lapse seismic surveys, which can reliably detect relatively small volumes of CO_2 underground. Geochemical fluid sampling also gave good insights into the movement of CO_2 within the reservoir and could detect any CO_2 breakthrough at wells.

IEA Green House Gas Weyburn-Midale CO_2 Monitoring & Storage Project—Final Phase

Phase 1 of the IEA project has provided a good foundation for the development of solid policy, regulations and operating practices for future CO_2 storage/EOR projects; however, there is more work to be done. The Phase 1 final report identified a number of important gaps and recommended a follow-up "Final Phase" to build a technical Best Practices Manual that outlines geological storage site selection protocols, injection strategies, effective technologies for tracking CO_2 through various geosciences technologies, completing and abandoning wellbores, and rigorous risk assessment strategies. Several gaps were identified at the end of the first phase of the project that will be addressed in the final phase project: understanding of the aging of wellbores over decades and centuries following abandonment, a credible peer-reviewed risk assessment approach, and a suite of cost-effective long-term measurement and verification protocols to track CO_2 movement underground. It was clear during the initial planning of the final phase project that information and advice could be provided to regulators for the development of advanced regulations based on incremental improvements of existing oil and gas regulations. Further, measurement, monitoring and verification (MMV) protocols would be identified during the project that would be valuable for crediting protocols. Governments and industry alike would derive benefits from completing the research at Weyburn through widespread knowledge and technology transfer. Demonstration of the integrity of geological storage at Weyburn would help to ensure public confidence in this greenhouse gas mitigation strategy through a proactive public communications and outreach program within the final phase project. The final phase of the project also includes the Apache Midale CO_2-EOR operation that began CO_2 injection in late 2006. We foresee a future where Weyburn has paved the way and future projects will not need to expend nearly as much research and monitoring resources to be assured of safe geological storage.

Next steps: Technical

Extensive investment and effort have been expended to get to the current level of understanding of geological storage at Weyburn but additional work is still necessary to develop cost-effective protocols to enable efficient site selection, design, operation, risk assessment and monitoring of future projects.

The key gaps identified in Phase I and the measures being taken in the Final Phase to address them and achieve win-win solutions include:

(i) Drafting of firm protocols for storage site selection.
(ii) Final selection of the most effective underground monitoring methods for CO_2 movements.
(iii) Identifying the most effective reservoir methods for maximizing storage capacity and oil recovery.
(iv) Finalizing the development of the most cost-effective and credible risk assessment methods and risk mitigation techniques to ensure the integrity of the storage medium.

Next steps: Non-technical

Advancement of the technical aspects of CO_2 storage is a necessary but insufficient requirement for the management of geological storage of CO_2 on a large scale. A successful CO_2 geologic storage "industry" must encompass a suite of technologies linked by a network of institutions, financial systems and regulations, along with public outreach activities, that are able to achieve broad public understanding and acceptance. Additional work is necessary in the following areas.

Regulatory Issues

For CO_2 storage to flourish, a predictable, science-based regulatory regime needs to be in place. Fortunately, regulations governing the injection of acid gases with a CO_2 component and other industrial applications are already in place. A complementary regulatory framework for long term storage applications with respect to safety and reliability may be required.

The experience from current provincial regulations on issues such as emergency planning and protection, health and safety, and drilling and well completion standards, as well as the fact the oil has been kept in the geological structure for many years should prove very helpful to future CO_2 storage regulatory efforts.

Finally, a transparent registry system should be created, with well-defined measurement protocols and verification requirements, to ensure proper accounting for greenhouse gas reductions created by geological storage and recognition of offset credits.

Public outreach

Geological Storage of CO_2 is increasingly recognized as a pragmatic way to address CO_2 emissions. An effective public outreach and consultation process could be helpful to ensure public understanding and acceptance of geological storage as a viable means of CO_2 sequestration. The technology needs to be communicated to the public in the context of GHG mitigation options, with clear explanations regarding why it is safe and viable over the long-term.

Current Status—Final Phase

The initial technical research package was approved by the sponsors in November 2006 along with a first year budget of $2.9 million (Canadian). Several research agreements are in place with research activities underway2. A number of agreements are pending execution. The technical research program is being expanded in a carefully managed and stage-gated process to ensure that results are directly applicable to the needs of a comprehensive Best Practices Manual, regulatory and policy advice and public outreach activities. Final phase project activities are integrated by four theme leaders in: geological characterization, wellbore assessment, geophysical and geochemical CO_2 tracking, and risk assessment. Semi-annual coordination meetings are held with all researchers and sponsors to ensure dissemination of information and research prioritization on a continuous basis. International interest in this research project remains strong with new industry sponsorship coming from Apache Canada, Saudi Aramco, OMV Austria and Schlumberger. Sponsorship from the public sector remains strong from U.S. Department of Energy (NETL), and the Governments of Canada, Saskatchewan and Alberta. The project continues to be endorsed by the IEA Greenhouse Gas R&D Programme, with further endorsement coming from the Carbon Sequestration Leadership Forum since 2004.

Conclusion

It is EnCana's hope that the experience at Weyburn will enable the start-up of a significant number of commercial-scale EOR-based CO_2 geological storage projects, a win-win scenario for the economy and the environment. These projects would provide substantial environmental benefits by enabling the geological storage of significant quantities of CO_2 that would otherwise be emitted to the atmosphere. Ramping up development of CO_2-based EOR projects would also increase oil recovery and hence improve energy security. Conventional methods in North America may only recover approximately 30% of oil in place, leaving a tremendous resource in the ground for EOR.

Although EnCana's activities have focused on EOR-based operations and not on other storage alternatives such as deep saline aquifers or coal bed methane, many of the operating practices so developed would be applicable to these other storage alternatives. Furthermore, the operating practices developed for Weyburn's geological environment would also be transferable to other sites with different geological characteristics. EOR projects currently represent the storage alternative that is the closest to being economic and with the right policy and regulatory framework, market signals and economic conditions, a number of projects could realistically be initiated.

Finally, Weyburn, particularly the IEA GHG Project, demonstrates the power of collaboration and partnerships between governments, researchers and industry to unlock value through technology. The research was valuable to EnCana as it helped the company to better understand its oil field and to innovate (e.g. CO_2 monitoring by four-dimensional seismic survey). It provided the opportunity for a Canadian research centre to develop expertise and potentially become a world leader in CO_2 geo-

logical storage monitoring and assessment. Finally, it has enabled government to advance their innovation, technology and sustainability agendas.

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2. Knudsen, R. and Preston, C.K., Update of the IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project—Final Phase, 7th Annual Conference on Carbon Capture and Sequestration, Pittsburgh, PA, USA, May 5-8, 2008.

[1] ADVISORY ON FUTURE-ORIENTED INFORMATION: In the interest of providing EnCana Corporation ("EnCana" or the "Company") shareholders and potential investors with information regarding the Company and its subsidiaries and the proposed transaction to form GasCo and IOCo and management's assessment of the Company's future plans and operations, certain statements or information in this document contain "forward-looking statements" within the meaning of the United States Private Securities Litigation Reform Act of 1995 or "forward-looking information" within the meaning of applicable Canadian securities legislation. Forward-looking statements or information in this document include, but are not limited to, statements with respect to: the future production potential and ultimate recoveries from the Weyburn project; the amount of CO_2 which may be injected at Weyburn; the projected quantity of incremental production resulting from CO_2 injection and projections for geologic storage of CO_2 at Weyburn and the potential efficacy of CO_2 sequestration on climate change; the ability of the Company to realize the long-term opportunity to undertake large-scale carbon capture and storage; the proposed transaction to form GasCo and IOCo and expected future attributes of each of GasCo and IOCo following such transaction; and the anticipated benefits of the transaction.

You are cautioned not to place undue reliance on forward-looking information, as there can be no assurance that the plans, intentions or expectations upon which it is based will occur. By its nature, forward-looking information involves numerous assumptions, known and unknown risks and uncertainties, both general and specific, that contribute to the possibility that the predictions, forecasts, projections and other forward-looking statements will not occur. Although the Company believes that the expectations represented by such forward-looking statements are reasonable, there can be no assurance that such expectations will prove to be correct. Some of the risks and other factors which could cause results to differ materially from those expressed in the forward-looking statements contained in these responses include, but are not limited to: volatility of and assumptions regarding crude oil and natural gas prices, assumptions based upon the Company's current guidance, fluctuations in currency and interest rates, product supply and demand, market competition, risks inherent in the Company's North American and foreign oil and gas and midstream operations, risks inherent in the Company's marketing operations, including credit risks, imprecision of reserves estimates and estimates of recoverable quantities of oil, bitumen, natural gas and liquids from resource plays and other sources not currently classified as proved reserves, the ability of the Company and ConocoPhillips to successfully manage and operate the North American integrated heavy oil business and the ability of the parties to obtain necessary regulatory approvals, refining and marketing margins, potential disruption or unexpected technical difficulties in developing new products and manufacturing processes, potential failure of new products to achieve acceptance in the market, unexpected cost increases or technical difficulties in constructing or modifying manufacturing or refining facilities, unexpected difficulties in manufacturing, transporting or refining synthetic crude oil, risks associated with technology and the application thereof to the business of GasCo and IOCo; the Company's ability to replace and expand oil and gas reserves, the Company's ability to either generate sufficient cash flow from operations to meet its current and future obligations or obtain external sources of debt and equity capital, general economic and business conditions, the Company's ability to enter into or renew leases, the timing and costs of well and pipeline construction, the Company's ability to make capital investments and the amounts of capital investments, imprecision in estimating the timing, costs and levels of production and drilling, the results of exploration and development drilling, imprecision in estimates of future production capacity, the Company's ability to secure adequate product transportation, uncertainty in the amounts and timing of royalty payments, imprecision in estimates of product sales, changes in royalty, tax, environmental and other laws or regulations or the interpretations of such laws or regulations, political and economic conditions in the countries in which the Company operates, the risk of war, hostilities, civil insurrection and instability affecting countries in which the

Company operates and terrorist threats, risks associated with existing and potential future lawsuits and regulatory actions brought against the Company, and such other risks and uncertainties described from time to time in the Company's reports and filings with the Canadian securities authorities and the United States Securities and Exchange Commission. Accordingly, the Company cautions that events or circumstances could cause actual results to differ materially from those predicted. Statements relating to "reserves" or "resources" or "resource potential" are deemed to be forward-looking statements, as they involve the implied assessment, based on certain estimates and assumptions that the resources and reserves and resource potential described exist in the quantities predicted or estimated, and can be profitably produced in the future. You are cautioned that the foregoing list of important factors is not exhaustive. You are further cautioned not to place undue reliance on forward-looking statements contained in these responses, which are made as of the date hereof, and, except as required by law, the Company undertakes no obligation to update publicly or revise any forward-looking information, whether as a result of new information, future events or otherwise. The forward-looking statements contained in these responses are expressly qualified by this cautionary statement.

Response to questions submitted for the record by Mark Demchuk, Team Lead, Weyburn Unit

Mr. Demchuk, when the firm protocols for storage site selection are drafted, will those be just for fields where enhanced oil recovery is taking place, or will they be broadly applicable?

Response:

We (EnCana) believe that the protocols will be most relevant to enhanced oil recovery applications. However, there will likely be some relevance to other storage technologies, but how applicable remains to be seen.

Mr. COSTA. Thank you very much, Mr. Demchuk. For those of you who are focused on when we may have to recess, we are told votes will be between 11:15 and 11:30. So I suspect they will be any time here in the next 10 minutes. We will try and see how far we can go on the Q and A round prior to that. We usually have 15 minutes-plus when the first roll call is required.

So let us begin. Mr. Demchuk, you mentioned that the extensive pre-injection baseline monitoring and time-lapse seismic studies at Weyburn, and Weyburn obviously is a model that we are all looking at. Will it be necessary to include those at other EOR sites? And are there other methods for monitoring the carbon dioxide that may not be as costly or take as long?

Mr. DEMCHUK. Well, certainly we have enjoyed and used with great success 3-D seismic, and now 4-D seismic technology to, first of all, baseline the reservoir conditions, and then map and track the movement of CO_2 within the reservoir since we started injecting.

Just to distinguish the difference between 3-D and 4-D seismic, 4-D really means time-stamped. So you take a three-dimensional seismic picture, and you are able to time-stamp it and follow the movement of CO_2 within the reservoir.

Mr. COSTA. So as you apply that 4-D in future efforts, does it make them less costly?

Mr. DEMCHUK. No, price doesn't really change. We spend about $2 million a year redoing the same seismic shoot to track the movements of the CO_2 within the reservoir.

Mr. COSTA. At the end of the day, does the Weyburn project end up storing more carbon dioxide per barrel of oil than produced in other enhanced oil recovery projects?

Mr. DEMCHUK. Well, I can't really say that we are going to store more CO_2 per barrel of oil produced. We do anticipate that at the end of the useful life of the EOR project, we will continue to be able to store CO_2 as a straight-up CO_2 storage project.

Mr. COSTA. Mr. Duncan, short of putting a price on carbon, are there specific actions you think the government should take to really kick-start this storage effort for industrial carbon dioxide through EOR?

Mr. DUNCAN. Well, I think solving the cost discrepancy that Tracy Evans referred to, I think the other thing that we can do is an active research program.

The understanding that we have of CO_2 EOR in the Permian Basin doesn't help us a lot once we move outside the Permian Basin, because the geological characteristics of the oil reservoirs are quite different. So we are going to have to have different approaches if we want to maximize oil recovery.

Mr. COSTA. One size doesn't fit all.

Mr. DUNCAN. Exactly.

Mr. COSTA. Have you had a chance to look at any of the cap-and-trade proposals that have been kind of percolating around here?

Mr. DUNCAN. To tell you the truth, cap-and-trade proposals make my head hurt.

Mr. COSTA. I am glad I am not the only one.

Mr. DUNCAN. So I try to avoid that activity.

Mr. COSTA. All right, all right. What is your take on whether or not this issue is, as carbon dioxide is defined, as a waste or a commodity?

Mr. DUNCAN. It is an issue that I don't find terribly exciting. I think the important thing is that we clear the way to increasing CO_2 EOR. I don't find those kind of legal nitpickings particularly exciting.

I think if there is clear legislation on the Federal level, that it will clear away any uncertainties related to terminology and semantics.

Mr. COSTA. This question is for everyone on the panel, and you will have to be brief because my time is going.

The Department of Interior recently concluded tax policies and grants focused on research and development. Some of you indicated in your testimony that in terms of enhanced oil recovery, it would be more effective in terms of royalty relief. Do you agree with that? And can anyone tell me what you think the current price of carbon dioxide is, and how closely that is related to the price of oil?

Mr. Roby, let us begin with yourself.

Mr. ROBY. We have various pricing for CO_2 based on the long-term contracts that we have had. Some do slide with the price of oil. So yes, the price of CO_2 is a function of oil price.

Mr. COSTA. And in terms of royalty relief for produced oil?

Mr. ROBY. Would you repeat the question, Chairman?

Mr. COSTA. The conclusion that tax policies and grants, and I think you said it in your statement, you would rather have royalty relief than grants. Is that correct?

Mr. ROBY. Right, right. As you know, CO_2 projects are a long-term project. The price of oil is certainly an uncertainty. We would

like to be able to put as much certainty in there as we could. Royalty relief we think would be helpful.

Mr. COSTA. Yes. Quickly, since everything is local, you have a plant in my area that you are developing, Occidental is, for enhanced oil recovery. Could you tell us more about that project?

Mr. ROBY. Well, we are in negotiations, and there is ongoing discussions for a plant out there. It is just in the discussion stage; things are being negotiated and talked about. There has been a public release by the parties involved in it.

We are talking to other companies, as well, so that is just one of several that we are just in the talk——

Mr. COSTA. I will get additional information from you later on. My time has expired, and therefore so has everybody else's. But we will get to a second round here, because we have I think a lot of questions.

The gentleman from New Mexico, the Ranking Member, Mr. Pearce.

Mr. PEARCE. Thank you, Mr. Chairman.

Mr. COSTA. And after, I think, when you complete your questions, we will probably have to go and vote. I assume the roll call has started?

OK. Go ahead, Mr. Pearce.

Mr. PEARCE. Mr. Roby, on the whole idea of using CO_2 as sequestration, is this an activity that a startup firm could be involved in? In other words, I am trying to get an idea of the magnitude of experience necessary. So could we just say a power company built a plant, and then start pumping CO_2 down in the ground right there where it is?

Give me just a brief answer about that.

Mr. ROBY. As you know, it is very complex. It is very costly. Injecting CO_2 in the ground takes huge economic analysis.

And so to answer your question, I would say no, it is not for a small startup company. It takes a company with a long-term perspective. It is costly, and, you know, with it being costly, it does take experts to understand the implications of where the CO_2 is going, the correct monitoring, and the correct processing.

Mr. PEARCE. We will have the staff hold the chart up here. What I am saying here is there is some field there, looks like in west Texas, eastern New Mexico, where I live and we made, our business was there. So I am seeing a curve, the green curves show the amount of oil that comes. But I am seeing constant, constant redrilling and then in-in-filling of the field to create that high peak of oil that we get.

But then we see that the oil that is retrieved against the decline out here. Where we put the red graph on, that is where you begin to inject and do more in-filling. And so the only way we are able to extend the life of that field is through this enhanced oil recovery. But that enhanced oil recovery is, percentage-wise, still a very kind of small portion of the total field. Is that a correct——

Mr. ROBY. That is correct. In fact, that appears to be for the entire Permian Basin. And that is right. It looks like we have all water flood primary and secondary recovery there.

And the CO_2 recovery, though it is extremely valuable to extend the reserves, it is, just makes a small percentage. We talked about

today 15 percent recovery. So most of the recovery is going to be from primary and secondary.

This is, it is not a silver bullet. It is helpful, but it will not solve all the problems that we have with energy.

Mr. PEARCE. Now, I have heard speculation that there is currently legislation that is being drafted to just shut off the natural sources of CO_2. What effects would that have on this field, and employment, the output, if we had legislation that just stopped the natural-occurring sources of CO_2?

Mr. ROBY. It would be devastating. In short, CO_2 production is significant in the Permian Basin. There is quite a bit looking in other parts of the country. If we shut down using natural-occurring CO_2, as talked about with the immature capturing CO_2 from industrial locations, and without the infrastructure, we would shut down a tremendous amount of oil production in the United States. And unemployment would be significant in your home state, as well as west Texas.

Mr. PEARCE. Mr. Demchuk, your observations on the same issue.

Mr. DEMCHUK. Well, from a production perspective, I didn't bring it, but I have a very similar chart that shows the production of the Weyburn field, which is 50 years old. And, as Mr. Roby described, the bulk of our production will have come from primary production and water flood, and we are simply extending the life of the field and increasing our production in the neighborhood of about——

Mr. PEARCE. So if we lost the source of naturally occurring CO_2 and mandated only carbon sequestration sources.

Mr. DEMCHUK. Well, actually, for us it would make no difference, because we use manmade CO_2 from a coal gasification facility.

Mr. PEARCE. And even in your U.S. operation—you have U.S. operations?

Mr. DEMCHUK. Not on the EOR side of the business. Our U.S. operations are primarily gas production.

Mr. PEARCE. Mr. Duncan, do you have any idea about how long it would be before we really are able to seriously harvest CO_2 in the United States for enhanced oil recovery? Just a number of years. Just a guess is fine.

Mr. DUNCAN. Well, I can give you more than a guess. If you started a project now, probably five to seven years to build capture plans. And I asked some people in Kinder Morgan how long they thought it would take to bring in, and they said four to seven years, so that is sort of consistent.

Mr. PEARCE. OK. Mr. Chairman, I see my time has elapsed. I have more questions. We will wait until the second round, and I know we have to go. Thanks.

Mr. COSTA. Thank you very much, Mr. Pearce. I would advise those on the second panel and those in the audience, we will be gone for at least half an hour. So my best guess is that we will begin probably some time after 12:10, 12:15. So if you have an opportunity, want to get a cup of coffee or use the facilities, or whatever.

But I know there is interest by the gentleman from New Mexico and myself, and we will have a second round of questions. And so we will see you in about half an hour. Thank you.

The Subcommittee is now in recess.

[Recess.]

Mr. COSTA. All right. I think we have our panel back. It took a little longer than we had anticipated. I apologize for that. But we are going to try to get in another round here with the members that are here, and we will bring this to a close.

I think we ended with the gentleman from New Mexico, Mr. Pearce's questioning, and so I will start off here on the second round.

Mr. Evans, what are you doing that is feasible offshore? We know that production rates have declined, especially on the shallower wells offshore of the Gulf. So could this technique be used there?

Mr. EVANS. Mr. Chairman, Denbury is currently not doing anything offshore, but there is no technical reasons why you can't do CO_2 EOR offshore. It becomes more of an economic issue of taking the CO_2 offshore. And generally in the offshore environment, the costs just go up to do the same thing that you are doing onshore.

But there is no technical reason why you can't do CO_2 EOR offshore.

Mr. COSTA. You talked about, and Mr. Pearce pointed out the issue with the pipelines, and we understand that access is important, if there was a change in the tax code that would provide incentives, do you think there would be much investment in the private sector to deal with the pipeline, the transmission capacity?

Mr. EVANS. I think there would be a great deal of interest in building more pipelines for CO_2. Most of your pipeline operators, what they want to really have assurance of is that there is going to be throughput through that pipeline.

So not only would it encourage investment, but it would also lower the total cost of, delivery cost of anthropogenic or manmade CO_2, as well.

Mr. COSTA. You also mentioned, I guess, in your comments about the tax credit for the CO_2 EOR that was almost enacted last year. Do you think that is enough to incentify the construction for pipelines?

Mr. EVANS. Well, the tax credit actually is for the capture of the CO_2, not necessarily the pipelines. The issue that we see is, as Denbury is, the actual oil and gas companies can build or pay for, in terms of CO_2 costs, most of the pipeline infrastructure. And we can only cover a portion of the capture costs, depending on which source it is coming from.

Obviously the lowest capture cost we believe is future gasification projects. And as you go up from there, then we can only cover a lesser and lesser amount.

Mr. COSTA. OK. Mr. Roby, and I guess maybe Mr. Evans, do either of your companies have plans for converting your fields to storage at the end of the EOR operations? And what would be the legal or regulatory or financial impediments if you did so?

Let me start with Mr. Roby.

Mr. ROBY. As far as plans, we don't have plans at this point in time. However, we do recognize that after we inject quite a bit of CO_2 in these fields, that the CO_2 will stay there. So the natural process does store CO_2.

We also recognize that CO_2 is quite a commodity. And if we can take that CO_2 in a field that has used it, and we depleted the oil resource from that field, we would then take it to another field.

So since we have invested tremendous millions of dollars for the CO_2, we are going to try to have that contacting as much oil as possible.

Mr. COSTA. Well, with that statement made, where do you see this EOR effort going in the next 10 or 20 years from Occidental's perspective?

Mr. ROBY. We are excited about CO_2 flooding, as we have been in the past. We want to continue to grow it. We want to continue to put CO_2 flooding in the Permian Basin.

As you know, we have looked at other areas of the country, and we are currently investigating that. We hope that it will grow into other regions beyond the Permian Basin. And in the fields that have not been taking CO_2 we are continually growing that, and we plan to continue to do so.

Mr. COSTA. Mr. Evans?

Mr. EVANS. We don't currently have that necessarily in our business model. We are going to also continue to expand. We are planning now with the three contracts to take anthropogenic volumes of CO_2, so we are going to sequester through EOR. But taking those fields beyond the EOR, we have not put that in our business model.

We are aware that a lot of our oilfields are sitting right in amongst saline reservoirs, as well, and so we are cognizant of that. And we fully expect our pipelines, once EOR is over, to be able to be utilized for the transportation of manmade for storage.

The second part of your question was the impediments. I think the biggest impediment right now is determining legally who owns the pore space.

Mr. COSTA. Who owns the——

Mr. EVANS. The pore space, where the CO_2 will be captured. There is no clarity on that issue yet. I know several states have been working on that, and right now they are not necessarily in agreement, either. So that is probably the biggest impediment. Access to land, and then who owns that pore space.

Mr. COSTA. Dr. Kunkel, you mentioned you effectively need a cap-and-trade system to make your project economic. Is there a price for carbon dioxide that would make it economic? Or would you say there is another way of partnering with oil producers?

Mr. KUNKEL. Well, a price for carbon dioxide is necessary. You know, the exact price also depends on a lot of other varying commodity prices, such as electricity market prices in Texas, coal price, and so on.

But if there was a market price of CO_2 emission reduction of \$20 to \$25, it would start to look very good for us.

Mr. COSTA. OK, my time has expired. The gentleman from New Mexico, Mr. Pearce.

Oh, I am sorry.

Mr. SALI. Mr. Chairman, you missed me on the first round.

Mr. COSTA. No, I know, and I am going to do my mea culpas right now.

Mr. SALI. How would you like to handle that? I can take 10 minutes on the second round, or I can go now and take up my first round.

Mr. COSTA. Why don't we alternate, Mr. Scalise? I am sorry, Mr. Sali.

Mr. SALI. You want me to go now? I am sorry.

Mr. COSTA. Yes.

Mr. SALI. OK. Mr. Roby, you mentioned in your testimony I think that Occidental has been involved in enhanced oil recovery for 30 years. In addition to carbon dioxide injection, what other types of enhanced oil recovery has your company been using?

Mr. ROBY. We were active in steam flooding in the United States, and also in the Mid-East. We are currently putting in those first large commercial steam flood in the Mid-East; it is a very large project in Oman.

We are also looking at chemical flooding in the domestic arena, both in Texas and California, as well as we are looking in Latin America and in the Mid-East. So we are actually active in EOR projects in the three areas that we operate, which is Mid-East, North Africa, Latin America, and the United States.

Mr. SALI. Now, with respect to the total enhanced oil recovery efforts that your company is involved in, what percentage of that is from carbon dioxide injection? Just approximately.

Mr. ROBY. A third. It is about—no, that is too high. It is about 20 percent for CO_2.

Mr. SALI. Is it fair to say that you anticipate this will be a growing area? Or other types of enhanced oil recovery would grow with that? Or what do you see for the future?

Mr. ROBY. We see it as growth. Will it grow on a percentage basis on CO_2? I am unsure about that, because we want to grow in other areas where we are not putting in CO_2 floods.

I will tell you that we are looking at putting in CO_2 floods in other continents, as well. But we do believe ultimate production will grow through CO_2.

Mr. SALI. As we look, I am reminded of the chart that was shown a little earlier. It looks like in the Permian Basin, there is a declining amount of recovery that is going to come from that basin, total recovery.

Mr. ROBY. Right. Yes, sir.

Mr. SALI. When we talk about enhanced oil recovery using CO_2 injection, what percentage of the total crude oil needs for the United States will that produce?

Mr. ROBY. Well, let me quantify. CO_2 production in the Permian Basin is in the tune of about 200,000 barrels a day. And I believe your question is what percent of that is the total domestic production?

Mr. SALI. I am actually looking at the feasibility of carbon dioxide injection and the recovery that we will get from that, not just from your company, but other companies. Do you have any kind of a guess about what percentage of our energy needs going forward we can rely on from this?

Mr. ROBY. In opening comments by the Chairman, it was said that there is no silver bullet. I agree with that completely.

This will help. I believe that we can, you can hope to get in the tune of 15 percent to 20 percent recovery from CO_2. There is, by no means every reservoir is capable of producing CO_2. I do believe that there is many reservoirs in the Gulf of Mexico that aren't floodable by CO_2, just due to gravity override. The permeability and the precocity is such that the testing that has been done in some areas shows that CO_2 will actually rise to the top, so in fact it was not a very good formation for producing CO_2, or for using CO_2 to produce.

So as a result of that, I think it is a little helpful, but in the tune of—and this is an educated estimate—a small percent, let us say 10 percent, in that tune.

Mr. SALI. You think that we could have as much as 10 percent of the total production for the United States——

Mr. ROBY. Oh, no. Oh, no, not in total. What I mean is that if you look at floodable areas, you could potentially recover 10 percent. But if you look at that in the, in total of floodable fields, it is a smaller percent than that. Because again, there is many fields that you can't put CO_2 in; it is just not amenable to this process.

Mr. SALI. Here is what I am trying to get at. If we are going to look forward and meet the energy needs of this country, to what extent can we rely on CO_2 injection? To what extent are we going to have to rely on new production exploration to give us new production in areas where we aren't today? How does this fit in that puzzle?

Mr. ROBY. We are going to have to have new primary production and water flood production. There is no question about that. CO_2 will help, but again, it is not going to be the savior. It is going to help.

Quantification, we have 200,000 in today. You could double that, say 400,000, wildly. That is still just 10 percent of total production in the United States. But clearly below what our consumption is.

Mr. SALI. Thank you. Thank you, Mr. Chairman.

Mr. COSTA. I thank the gentleman from Idaho. And again, I was not intentioned to avoid your time there.

Mr. SALI. That is fine.

Mr. COSTA. I try to be fair.

Mr. SALI. All right.

Mr. COSTA. Mr. Evans, what kind of plants are you getting your industrial carbon dioxide from?

Mr. EVANS. We plan to get it from three basic plants. One is a coal-to-liquids plant, one is a pepcoke-to-ammonia plant, and the other is more than likely going to be pepcoke to a combination of ammonia and methiodal.

Mr. COSTA. How much more expensive is the natural gas than the carbon dioxide pipeline?

Mr. EVANS. How much is the manmade CO_2, or natural gas?

Mr. COSTA. How much more expensive is natural gas?

Mr. EVANS. Well, natural gas is about $12 per NCF. You know, manmade CO_2 is probably going to be in the neighborhood of, you know, depending on negotiations, somewhere between a dollar and two dollars.

Are you talking about natural CO_2?

Mr. COSTA. Yes. I am sorry, I don't think I was clear on my question. I am talking about the price of the pipeline.

Mr. EVANS. Oh, the price of the pipeline? Oh. On a per-inch mile, generally the prices won't be that much different on the pipelines. The big difference between pipelines is we have a heavier grade of steel, because we generally operate CO_2 at 2200 psi or greater, where a natural gas pipeline would be 1200.

So what you would see is a slightly higher price for the actual pipe, but the construction would be closer than that. My best estimate would be probably in the neighborhood of 15 percent to 20 percent more.

Mr. COSTA. OK. Dr. Kunkel, are you working closely with the Department of Energy on attempting to, with the new plan, I think we had a description in your submitted testimony, in terms of funding for the captured portion of the plant you described?

Mr. KUNKEL. We have submitted information about our project in response to the recent information request that they have about various carbon-capture and gasification types of projects. And so they have our information; they know of our interests, and we are aware of their interests. They have a process going forward which may take some time.

Mr. COSTA. Will you still build your plant if you don't have the capture piece?

Mr. KUNKEL. We do not intend to build a plant without the capture piece. We see it as, you know, part and parcel of this project.

Mr. COSTA. All right. Professor, you clearly have been in the field for a number of years. Where do you see this all going in terms of the potential? I mean, we are trying to combine challenges here that we have with CO_2 levels, we are trying to obviously enhance our oil and gas recovery. We are in an energy crisis. I think a number of us have made the comment that there is no silver bullet. I think that is true, there is no silver bullet.

I guess the policy debate we are having here in Washington is what is the proper mix between additional domestic sources, both onshore and offshore, enhancing our older fields, and dealing with other alternative forms of energy.

Where do you, in terms of your focus, where do you stand down there at Texas University?

Mr. DUNCAN. In terms of my personal focus, I agree with Mr. Roby about the fact that CO_2 EOR is not going to have a huge impact on domestic oil production. It can have a very meaningful impact, but it is not going to turn the ship around.

However, it can have a meaningful, a really meaningful impact in terms of CO_2 sequestration. It can play a significant role. It can also play a very significant role in developing the infrastructure that can later be used for brine sequestration.

Mr. COSTA. The infrastructure part I get. But in terms of the significant role of the capture, how do you describe a significant impact? I mean, what in your mind constitutes, I guess, a significant impact?

Mr. DUNCAN. Well, I think a significant impact would be if you look at the Princeton people's wedge idea of tackling the CO_2 problem, if you could capture 10 percent of the CO_2, or 20 percent say in the Gulf Coast and the other oil-producing areas as susceptible

for CO_2 EOR, I think that would be a big chunk of a U.S. contribution toward a carbon-constrained world.

Mr. COSTA. And then that technology would be applicable in other parts of the world.

Mr. DUNCAN. Exactly, yes. As a matter of fact, if CO_2 sequestration is going to occur anywhere in the world, it is basically going to take place with technology developed in the U.S., in the Gulf Coast, in Texas. And it is going to require expertise from those people who have been doing CO_2 injections for the past 35 years or so.

Mr. COSTA. And we have the expertise here.

Mr. DUNCAN. We have the expertise. We have the knowledge, we have the understanding. We need more of it, but we have a lot of it.

Mr. COSTA. All right. My time has expired. The gentleman from New Mexico, Mr. Pearce.

Mr. PEARCE. Thank you, Mr. Chairman. Mr. Roby, how much would the price of gas go up, gasoline at the pump go up if we were to shut off naturally occurring sources of CO_2 today? And I worry about that. I listened with extreme concern as Maxine Waters described the process where the government might take over and run the oil companies. And so I really have great fears about what the intent of the majority is.

So what would be the cost? What would happen to the price of gasoline, in your estimation?

Mr. ROBY. Well, Occidental is not in the refining and marketing business, so we have no, so we don't have an arm of that.

However, you mentioned in my estimation. I just know that the price is a function of supply and demand of the base product, and the supply of crude would go down. As I mentioned early in my remarks, I believe not using naturally occurring CO_2 would be devastating. And we could easily pull out 200,000 barrels a day from the Permian Basin, and potential growth beyond this.

So all I can tell you is directionally, it would go up. And I think it would certainly not be good for the energy of this country.

Mr. PEARCE. You have heard Mr. Evans's optimistic view about the investment that would be attracted by the, toward the building of pipelines. Do you anticipate that the building of any carbon dioxide-transmitting pipelines might be met with protests and with litigation?

Yesterday I think one of the Circuit Courts handed down a decision that a refinery can't be built, so again we have made another decision not to build refineries in this country yesterday. Do you think there would be any objections by groups that don't want these pipelines built?

Mr. ROBY. There will always—yes.

Mr. PEARCE. Yes. And how far along would you think that we, to get a series of pipelines across the country that would feed all of the, all of the fields that are hospitable to CO_2 injection, would you take a guess at how long it would take to get all that infrastructure through the courts and through the processes?

Mr. ROBY. It would be enormous. It has taken us decades to get to where we are today with natural gas. Permitting process is taking longer today than it was a decade ago.

I would venture to speculate that we are looking at 20-ish years.

Mr. PEARCE. Twenty years. Mr. Evans, would that dampen down the enthusiasm, all these people lined up to build these pipelines? Do you think they will keep their money on the docket for 20 years while they are waiting for the process?

Mr. ROBY. Well, I think, of course, we will——

Mr. PEARCE. I am asking Mr. Evans. Excuse me.

Mr. EVANS. Well, I think in order to build, you know, 500,000 miles in infrastructure, you say that would take 20 years. Individual pipelines in all producing regions, we don't see a lot of protests. We have not seen——

Mr. PEARCE. OK, but we are talking about building infrastructure across the entire country. And we are talking about significantly affecting the CO_2 that is available. And so yes, I know your situation is just from Sweetwater to the field.

Mr. EVANS. Right.

Mr. PEARCE. But I am asking a generalized question.

Mr. EVANS. Well, yes. People will invest in these pipelines as long as they are assured that they are going to be able to get put in.

Mr. PEARCE. Yes, they are not going to leave their money sitting on the table.

Mr. EVANS. Well, it won't be sitting on the table. It took almost 50 years to build the infrastructure we have today, but that is built out as you build volume.

So yes, we will face protests. We may or may not need eminent domain. But those kind of things can all be addressed.

Mr. PEARCE. And by the way, we just had a hearing here a couple weeks ago where people are protesting the corridors; we set up corridors in the 2005 Energy Policy Act to convey different forms of energy. And the protests are occurring that will probably stop that entire project. So I am just trying to keep our feet on the ground here, as we look with enthusiasm.

Mr. Evans, let us say that we do withdraw the naturally occurring sources of CO_2, and we see, say, a five-time increase in the price of carbon, would your company still do a CO_2 injection with a five-time increase?

Mr. EVANS. Well, five times increase from where our current——

Mr. PEARCE. An increase in the cost.

Mr. EVANS. Well, we probably would, because our CO_2 cost right now is very, very low. So five times our cost, we could still do it.

I don't think people in the Permian Basin and Rocky Mountains probably could accept that kind of increase.

Mr. PEARCE. Your project is based on Mr. Kunkel's building of his project, and his project is dependent on legislation. The European countries are finding that cap-and-trade is just too expensive. I think that might be what caused Mr. Duncan's head to hurt about it, that the European countries are backing away from it.

What are you going to do in your project if Mr. Kunkel doesn't build his? Are you still going to go ahead with your project to put CO_2 in the ground?

Mr. EVANS. Well, our primary focus is not power. Unfortunately, their costs are very, very high, especially for power not generated by gasification.

Mr. PEARCE. That is not my question. My question is, are you going to keep on the project if Mr. Kunkel doesn't build his project? Are you going to stay on your project?

Mr. EVANS. Well, not if I was only tied to his project.

Mr. PEARCE. But that is my question. You are so tied to it that you will not, is that my understanding?

Mr. EVANS. No, sir. Actually, Denbury and Tenaska are not tied together at all. In fact, we are not working on that project with them.

If that was a similar project in our area of the country, and that was our only choice of CO_2, no, that would, his price of CO_2 would not be economical for us to continue.

Mr. PEARCE. All right, Mr. Chairman. I have a lot to think about, I think. Thanks. I appreciate it.

Mr. COSTA. Thank you for your good questions, as always. Members of the panel, thank you for your patience. I am sorry that we had to have a break.

Mr. PEARCE. Wait, I am going to have unanimous consent to——

Mr. COSTA. OK. And obviously this is an issue that has a great deal of interest, and your testimony is focused on that. And we will continue to work with you as we try to chart a course that can continue this effort that I think has a lot of potential benefit to our country's energy needs.

Mr. Pearce.

Mr. PEARCE. OK. We have a report from the Department of Energy about enhanced oil recovery. I would like unanimous consent to submit that.

Mr. COSTA. Without objection.

Mr. PEARCE. And additionally, an editorial from yesterday's Investor's Business Daily, American Energy Production. I am requesting unanimous consent to submit that for the record.

Mr. COSTA. Without objection.

[NOTE: The article submitted for the record has been retained in the Committee's official files.]

Mr. COSTA. Anyway, once again, I thank the members of the Committee. Thanks to the staff. And I apologize for the way the hearing got elongated today. But your expertise and your information is very valuable, as we look at the policy considerations that we have to consider as we pursue hopefully that bipartisan energy policy that I think is in the best interest for all of America, given the energy crisis we are facing.

This hearing is now adjourned.

[Whereupon, at 1:04 p.m., the Subcommittee was adjourned.]

[Additional material submitted for the record follows:]

[A statement submitted for the record by George Peridas, Ph.D., Science Fellow, Climate Center, Natural Resources Defense Council, follows:]

Statement of George Peridas, Ph.D., Science Fellow, Climate Center, Natural Resources Defense Council

We thank the House Natural Resources Committee, Subcommittee on Energy and Mineral Resources for the opportunity to submit written testimony for its June 12th, 2008 oversight hearing on "Spinning Straw Into Black Gold: Enhanced Oil Recovery Using Carbon Dioxide". NRDC is a national, nonprofit organization of scientists,

lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington D.C., San Francisco, Los Angeles, Chicago and Beijing.

The Subcommittee's examination of the topic of Enhanced Oil Recovery using Carbon Dioxide (CO_2-EOR) is extremely topical. The United States are faced with two related challenges that demand prompt action: energy independence and climate change.

First, we must ensure that our nation can meet its energy needs securely, affordably and efficiently, without being subject to world energy price shocks or relying on unstable regions for its fuel supplies.

Second, as the developed world's largest greenhouse gas emitter—and until very recently the world's largest emitter[1]—we must also take prompt action to reduce these emissions substantially in order to avoid the worst effects of climate change on this country and the rest of the planet, as well as the significant costs associated with it, which will be significant for many regions of the country.

CO_2-EOR offers an opportunity to take positive action on both challenges by making use of an untapped domestic oil resource without the worst impacts of other production methods or proposals, while permanently sequestering CO_2 from anthropogenic sources underground. To put the opportunity in perspective, a recently updated survey of the CO_2-EOR potential in the United States prepared for the U.S. Department of Energy estimates that as much as 48 billion barrels of "stranded oil" from existing fields—more than double the approximately 22 billion barrels of proven U.S. reserves—would be economical to produce at recent years' high oil prices.[2] At $100/barrel, that amounts to $4.8 trillion tied to domestic oil reserves that would create a multi-decade market for more than 11.5 billion tons of CO_2, almost all of which will need to come from industrial sources that otherwise would be emitted to the atmosphere.

In our view, the urgent challenges of our national and global dependence on oil and escalating global warming pollution both demand rapid investment in efficiency and cleaner sources of energy. NRDC also believes that carbon capture and geologic storage from coal-fired power plants and other large industrial sources will be necessary to achieve the deep emission reductions that will be needed. We believe that CO_2-EOR, implemented with the appropriate measures to ensure long-term geologic sequestration, provides a very significant opportunity to advance carbon capture and storage, reduce industrial emissions and to sustain domestic oil projection without drilling in environmentally sensitive areas.

Our oil addiction

In his 2006 State of the Union address, President Bush famously admitted that America is addicted to oil. Indeed, the U.S. consumes oil at an astonishing rate of roughly 21 million barrels/day or a quarter of the oil produced globally, 70% of which is used in the transportation sector. According to the DOE-EIA Annual Energy Outlook, we import twice as much oil as we produce domestically, meaning that a staggering two-thirds of our oil is imported. Domestic oil production has been dropping steadily since the 1970s as the figure below shows, and the nation's dependence on imported oil is project to increase steadily according to the EIA. Depending so heavily on an imported resource so crucial to the economy is without question unwise—and the policy decisions that will affect whether this will be the case are being made today.

[1] Estimates indicate that China surpassed the U.S. in emissions in 2007.
[2] "Storing CO_2 with Enhanced Oil Recovery", DOE/NETL-402/1312/02-07-08, February 2008.

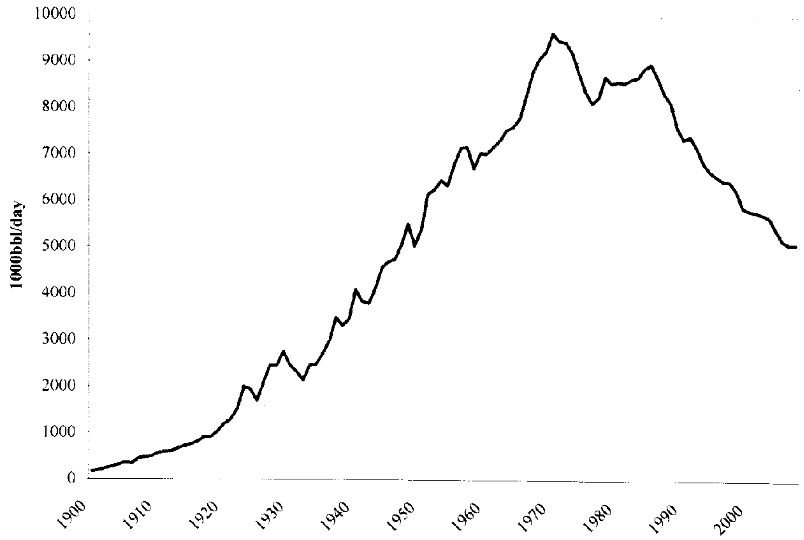

Figure 1 – Domestic crude oil production (thousands of barrels/day)

Until recently, the nation had grown complacent about oil use. The price of oil remained under $20/barrel in nominal terms for much of the 1990s, creating an illusion of an inexpensive commodity. Since 2002 however, oil prices have been climbing ever upwards, surging to almost $140/barrel in June 2008. It is clear that the era of cheap oil—and cheap fossil fuels more generally for that matter—is over in all likelihood. With strong demand in the developed world and an ever-increasing pressure coming from the developing countries, a world of high or rising oil prices is a distinct possibility and one predicted by several analysts.

The economic impacts of the recent surges are being felt worst of all by the poorest families and communities. Yet high prices have not slowed us down. Even in the context of sustained high oil prices in the last five years, fuel use trends remain largely unchanged, and our transportation fuel demand continues to rise relentlessly. Only now is evidence emerging that consumers are turning to more fuel-efficient vehicles and away from "gas-guzzlers", an effect that is making automakers resort to plant closures and shift their fleet to the kind of vehicle that ought to have been the obvious choice and the correct business decision long ago.

It does not take an expert to work out that our current path is unwise from an economic point of view, from a national security point of view, or from an environmental point of view.

A changing climate

Alongside surging oil prices and demand, the planet's climate is changing fast. Greenhouse gas emissions from the use of fossil fuels, mainly CO_2, are having a profound effect on our planet, presenting us with one of the most significant environmental and social challenges of the century.

In its most recent Assessment Report last year, the Intergovernmental Panel on Climate Change, an independent scientific body, issued the loudest warning to date, calling the warming in the climate system "unequivocal" and calling for serious emission reductions if we are to avoid truly dangerous greenhouse gas concentrations. Failure to pursue significant reductions in greenhouse gas emissions very soon will make the job much harder in the future—both the job of stabilizing atmospheric pollution concentrations and the job of avoiding the worst impacts of climate chaos.

A growing body of scientific research indicates that we face extreme dangers to human health, economic well-being, and the ecosystems on which we depend if global average temperatures are allowed to increase by more than 2 degrees Fahrenheit from today's levels. We have good prospects of staying below this temperature increase if atmospheric concentrations of CO_2 and other global warming gases are kept from exceeding 450 ppm (parts per million) CO_2-equivalent and then rapidly reduced. To make this possible requires immediate steps to reduce global emis-

sions over the next several decades, including action to halt U.S. emissions growth within the next few years and then cut emissions by approximately 80% by mid-century. This goal is ambitious, but achievable. It can be done through an annual rate of emissions reductions that ramps up to about a 4% reduction per year. Fortunately, a wide variety of tools is available today to achieve those reductions—but we will need all the tools at our disposal. One such tool is Carbon Capture & Sequestration (CCS).

Carbon capture & sequestration (CCS)

Given the world's and the nation's dependence on fossil fuels, it is essential to have in place a technology and a strategy to reduce greenhouse gas emissions from large industrial facilities that burn these fuels, even though their complete phase-out through energy efficiency improvements and a transition to renewable fuel sources might be technically and theoretically possible. Using all available tools is a wise and necessary hedging strategy in the face of the steep emission cuts that are needed. Projections differ as to the exact portion of reductions that will be delivered by different technologies, but from a strategic point of view, CCS provides a much needed answer for fossil fuel use—which is inevitable.

Coal by itself, the most carbon-intensive of fossil fuels presents the biggest climate challenge. Since the dawn of the industrial age, human use of coal has released about 150 billion metric tons of carbon into the atmosphere—about half the total carbon emissions due to fossil fuel use in human history. Another 4 trillion metric tons of carbon are contained in the remaining global coal resources. That is a carbon pool nearly seven times greater than the amount in our pre-industrial atmosphere. Using that coal without capturing and disposing of its carbon means a climate catastrophe. And the die is being cast for that catastrophe today, not decades from now. According to the International Energy Agency, over 1800 GW of new coal plants will be built between now and 2030, a capacity equivalent to 3000 large coal plants, or an average of ten new coal plants every month for the next quarter century. This new capacity amounts to 1.5 times the total of all the coal plants operating in the world today.

Continuing with the use of coal without capturing and sequestering is fundamentally incompatible with climate stabilization. NRDC believes that CCS technology is available to us today to begin deployment.

Research on CCS has been ongoing for many years now, with major international conferences taking place since the early 1990s. Since then, knowledge on the subject has greatly expanded, to the extent that the Intergovernmental Panel on Climate Change ("IPCC") issued a special report on CCS in 2005. An extensive Massachusetts Institute of Technology ("MIT") study on the Future of Coal in 2007 also examined CCS in depth. There is a substantial body of evidence, knowledge, and peer-reviewed literature on CCS.

In many ways, CCS is not new. There are three elements to successful geologic sequestration of carbon dioxide: capture, transportation, and sequestration. All three of these elements have been demonstrated and operated in commercial, large scale installations.

The first element of CCS is the initial capture of the carbon dioxide emissions. "Pre-combustion capture" is applied to conversion processes that gasify coal, petroleum coke, or other feedstocks (such as biomass) rather than combusting them in air. In the oxygen-blown gasification process, the feedstock is heated under pressure with a mixture of pure oxygen, producing an energy-rich gas stream consisting mostly of hydrogen and carbon monoxide. Coal gasification is widely used in industrial processes around the world, such as in ammonia and fertilizer production. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this "syngas" stream is cleaned of some impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle ("IGCC"). Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO_2, and then separating the CO_2 primarily through the use of solvents. These same techniques are used in industrial plants to separate CO_2 from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO_2 can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO_2 do not capture it; rather, they release it to the atmosphere. Notable exceptions include the Dakota Gasification Company plant in Beulah, North Dakota, which captures and pipelines more than one million tons of CO_2 per year from its lignite gasification plant to an oil field in Saskatchewan (the Weyburn project described below), and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO_2 from sour gas and pipelines several million tons per year to oil

fields in Colorado and Wyoming. The principal obstacle for broad application of pre-combustion capture to new power plants (and the main reason behind limited deployment of IGCC with carbon capture) is not technical, it is economic: under today's laws it is cheaper to release CO_2 to the air than capture it. Other capture technologies, including post-combustion and oxyfuel combustion are currently at the bench and/or pilot demonstration stage. The cost of CO_2 capture is by far the most expensive element in the CCS chain of operations, estimated to be in the region of 75% of total costs, depending on the geological setting and the distance of transport.

The second element of CCS is the transportation of captured carbon dioxide to the injection site, if needed. As we describe further below, CO_2 pipelines today operate as a mature market technology.

The third element of CCS is the sequestration of the carbon dioxide in geological formations. Injection of carbon dioxide has been successfully demonstrated on a large scale, not least in the context of CO_2-EOR projects, some of which like Seminole, SACROC and Wasson are injecting annual amounts of CO_2 well above the quantity that a 500MW coal plant would produce. There is also considerable scientific knowledge regarding the mechanisms for trapping carbon dioxide in sedimentary geological formations. For example, residual trapping limits carbon dioxide mobility through capillary forces. Solubility trapping occurs when injected carbon dioxide dissolves in fluids within the geological formation. Stratigraphic trapping occurs when overlying impermeable rock formations prevent upward movement of carbon dioxide from underlying reservoirs. Mineralization trapping occurs when injected carbon dioxide forms carbonate minerals and essential becomes part of the solid rock into which it was injected. Both the Intergovernmental Panel on Climate Change ("IPCC") and the interdisciplinary team from the Massachusetts Institute of Technology ("MIT") concluded that such sequestration methods in appropriately selected and operated geologic reservoirs are likely to trap over 99% of injected carbon dioxide over 1,000 years. This conclusion is based on existing project performance and a number of natural and industrial analogs. Nature itself has stored hydrocarbons and CO_2 for millions to hundreds of millions of years, and humans have successfully stored natural gas and other fluids underground.

There are several commercial and research projects that inject carbon dioxide in sedimentary geological formations for permanent sequestration. For example, the Sleipner project in Norway has been operating since 1996 and injects about 1 million tons of CO_2 annually into a deep saline formation in the North Sea. BP's In Salah project, operating in Algeria since 2004, injects a similar amount of CO_2 stripped from natural gas back into the water leg of the natural gas field. The Weyburn project receives CO_2 captured and transported from North Dakota to Saskatchewan and has been operating since 2000 and injects 1-2 million tons of CO_2 annually. All three of these projects include monitoring programs. The results of that monitoring indicate that the CO_2 is remaining sequestered in the formations and that there is no reason to expect any CO_2 leakage from these projects. These projects just mentioned give me a great deal of confidence that CO_2 can remain permanently sequestered in geological reservoirs.

All components of CCS therefore—capture, transportation and injection—have been demonstrated at commercial scale in a number of industrial applications. We believe that the barriers to CCS are not technological, but rather economic and regulatory. We are joined by leaders of major industrial corporations such as NRG Energy and BP, who have stated their case as follows:

> "We're Carboholics. Make Us Stop. We are not running out of time; we have run out of time. We need to move as quickly as possible toward implementing the low-emissions ways of combusting coal that are under development or, in the case of "coal gasification" technology, are ready for commercial deployment."

[David Crane, CEO of NRG Energy; Washington Post, October 14, 2007]

> "CCS cannot succeed as a commercially successful emission abatement technology without the policy or regulatory frameworks that would allow commercial entities to invest in it. New technology cannot be 'pushed' into industrial-scale deployment, a market is necessary to 'pull' it. Deploying CCS at scale is not as much a question of technology availability but of economic viability. CCS is available today to play a significant role in reducing greenhouse gas emissions and addressing climate change".

[Robert Malone, Chairman and President, BP America; Written Testimony Submitted to the Select Committee on Energy Independence and Global Warming U.S. House of Representatives, September 21, 2007]

The reason that no large integrated power sector CCS project exists today is purely economic: it is simply cheaper to vent the CO_2 under today's laws instead capturing it, compressing it, transporting it to a suitable reservoir and sequestering it.

However, this is not an indication of the state of readiness of the technology. The USDOE is also leading a national research program on CCS. Although we applaud the efforts of the dedicated and talented individuals involved in this program, the resources and funding available are not in line with the deployment timescale needed for CCS to reduce emissions meaningfully. Without an economy-wide cap-and-trade scheme that prices carbon emissions, and without targeted and reliably funded (such as auction revenues, as opposed to the notoriously unreliable appropriations) incentives to bring down the costs of CCS in the initial years when the carbon price is too low and volatile to spur investment, CCS is destined to linger in the background as it has done until now. We are convinced, however that, under such a policy framework, hundreds of MWs of power sector CCS would be deployed in the early years. The DOE's targets and timelines should not be seen as representative of the technology, or its program as the gateway to CCS.

Addressing energy independence and climate change

Weaning ourselves off foreign oil, while at the same time addressing climate change, is achievable if we make the right choices. In a world of climbing prices, increased dependence on imports, geopolitical instability and rising emissions, the obvious focus should be the more efficient use of energy and oil, and its replacement to the extent possible with cleaner, sustainable alternatives.

Solutions abound: more efficient vehicles, expanded use of public transport, smart city planning, low carbon fuels such as sustainably grown biofuels, plug-in-hybrid vehicles powered by low carbon electricity are all options that are available to us today. Our first priority should be to substitute oil by improving end-use efficiency, and by sustainable, low-carbon alternatives as fast as possible. These resources are cleaner, and the diversity that they will provide is our most powerful weapon against oil profiteers domestically and abroad. On the topic of domestic production, we should fully exploit the fields we have already explored and developed. America's existing oil fields hold billions of barrels of oil that we know are there and can be produced at reliable costs with no added environmental damage. CO_2-EOR is key to tapping this resource.

In order for these solutions to deliver on their potential, concerted policy efforts will be needed—and this will take decisive action, political vision and leadership. Now is the time to make the right choices on how to fuel our future growth, and to move in an efficient, low-carbon direction.

The false promises of drilling and unconventional fuels

In the face of high oil prices and energy security concerns, a number of proposals have been put on the table that would allegedly come to the rescue. These include drilling in environmentally sensitive or protected areas such as the Arctic National Wildlife Refuge (ANWR) or on the Outer Continental Shelf (OCS), or resorting to unconventional oil sources such as tar sands and oil shale.

Drilling in ANWR and on the OCS has been restricted in order to protect a few of the remaining special places in America from the industrialization that accompanies energy exploitation, and because an expansion of drilling in these areas will do precious little to benefit Americans—the U.S. can meet its energy needs without opening these areas to drilling and accompanying industrial activities. Both of these premises remain true today, even though unrelated forces have resulted in an increase in prices at the gas pump. It remains true that complete exploitation of these areas would not reduce America's transportation fuel bill. Efforts to expand drilling in those areas amount to nothing more than attempts by special interests to stockpile and secure market share. However, there are a combination of actions that can provide real and long-lasting relief while protecting these special places as part of the bargain.

The Arctic National Wildlife Refuge, a pristine area located in northeast Alaska, is the nation's second largest national wildlife refuge, comprising 19 million acres. It is home to nearly 200 wildlife species. Because of its abundant and diverse wildlife, the refuge is often likened to Africa's Serengeti. Scientists consider the coastal plain, which has been proposed for drilling, to be the biological heart of the entire refuge, containing caribou, polar bears, grizzly bears, wolves, and various migratory birds, several of which are protected by international treaties or agreements. The refuge was created in 1960 by Congress to specifically protect the region's wildlife.

In addition to the wilderness value of the refuge, drilling there will do nothing to relieve prices at the pump for a number of reasons, which are aptly summarized

in a recent report by Majority staff of this Committee[3], drawing on official departmental statistics and reports:

- It is not clear exactly how much oil could be extracted. It may be possible that up to 11 billion barrels of crude oil is in place. However, the amount of this oil that can actually be recovered due to technological and economic reasons is significantly less. In a recent study, the DOE's Energy Information Administration estimated that the cumulative additional oil production from ANWR could be as low as 1.9 billion barrels, with an upper estimate of 4.3 billion barrels.[4]
- A vast acreage is open and available for leasing in Alaska outside ANWR. However, companies have leased only a fraction of this land and produced very little or no oil.[5]
- It will take a decade before oil can be produced from ANWR, and another decade before oil production reaches its peak.
- The total production from ANWR would pale in comparison with total U.S. demand, and also in comparison to the production potential from CO_2-EOR from depleted fields.

Pretty much the same realities apply to drilling on the OCS. Drilling in these areas poses unacceptable environmental risks of oil spills, air and water pollution, seismic impacts on marine mammals and onshore damage. Drilling is not necessary, given that estimates by the Minerals Management Service (MMS) show that 60% of the untapped economically recoverable oil and 80% of the untapped economically recoverable oil and/or natural gas on the OCS are located in areas that are currently open for leasing to industry.

Perhaps most importantly, feeding our addiction does nothing to decrease our dependence on oil. Moreover, oil prices are set by global markets. There is absolutely no evidence to show that increased domestic production will result in more than a few cents worth of lower prices at the pump—in fact although between 1999 and 2007, the number of drilling permits issued for development of public lands has more than tripled, oil and gasoline prices have risen to today's levels regardless. We also cannot hide the fact that the local and cumulative impacts from the expansion in leases and permits has also been significant. Many leases are located in areas where the carrying capacity for development has been, or is very close to being exceeded, and in most areas development is taking place without an overall development plan or in a phased manner. Nor is the characterization of no-go areas accurate. In some regions such as California, despite the absence of "new" drilling for some years now, there a substantial ongoing legacy program. All in all, recent years have been characterized by a fury of domestic drilling under permissive federal regulators, with plenty of unused leases still available in reserve. Despite this activity, prices have soared and the share of imports has risen.

The only sound and possible way to decrease prices and ensure a secure energy supply for the nation is to move away from the paradigm of meeting uncontrolled demand growth, use oil more efficiently and to replace it with other, low-carbon fuels. We just cannot drill our way out of our oil dependence. Attempts to mislead the public into believing that the protection of sensitive areas from drilling is responsible for today's ills are irresponsible and not in the interest of the American people, who will ultimately be the judges of the policies that come out of Congress. Increasing fuel efficiency standards for new vehicles to 40 miles per gallon would save more than ten times the likely yield of oil from ANWR. It is short-sighted and unwise to think of degrading an irreplaceable refuge to get a few cents of relief from higher gas prices, rather than encouraging Detroit to make more efficient cars and employing Americans in clean energy jobs. Fortunately we moved a step closer to the right path this past year when Congress required automakers to build cars and light trucks that average at least 35 mpg by 2020. By raising the fuel-efficiency bar even higher, we will be well on our way to beating the addiction. The public has realized that, and automakers are feeling the impacts: only recently General Motors announced that it is closing four plants that produce sport utility vehicles and pickup trucks in North America, prompted by soaring gas prices and slumping sales in

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[3] "The Truth About America's Energy: Big Oil Stockpiles Supplies and Pockets Profits"; A Special Report by the House Committee on Natural Resources Majority Staff, June 2008.

[4] "Analysis of Crude Oil Production in the Arctic National Wildlife Refuge". Energy Information Administration Office of Integrated Analysis and Forecasting U.S. Department of Energy; May 2008

[5] Approximately 91 million acres are currently open to leasing in the Arctic region of Alaska onshore and offshore. Oil and gas companies have leased only 11.8 million of these. Within the National Petroleum Reserve in Alaska, around 3 million acres out of 22.6 have been leased. No oil has been produced those lands and industry has drilled only 25 exploratory wells there since 2000.

the area. At the same time, GM plans a new emphasis on compact cars and is reviewing the future of the giant "Hummer".

Unconventional fuels are no exception. In the name of energy independence and lowering gas prices, proponents would have us believe that producing transportation fuels from tar sands, oil shale and coal are a sensible solution. These resources can be accessed domestically in the U.S. or in friendly Canada just across the border. The technologies to convert these unconventional resources into fuels had seen very limited application for years due to their high cost and market risk, but current high oil prices are spurring a flurry of development. Tempting though these resources might seem, they carry a host of economic and environmental problems, and unsurprisingly are not the answer to our oil addiction either.

Whether it is scouring the earth for the tar-like substance mixed with sands excavated from under the Boreal forests of Alberta, Canada, mining shale under the U.S. Rockies, or stripping coal from the mountains of the American West and Appalachia to manufacture synthetic liquid fuel, these unconventional sources constitute a heavy environmental burden to communities and ecosystems—both local and global.

Fuel production from these sources is extremely energy intensive, and the production process emits a far higher amount of greenhouse gas emissions than conventional oil production—often whole multiples of that amount. In a carbon-constrained world, these fuels will have to shoulder the additional cost of their high carbon content, and will not fare well either under cap-and-trade regimes or low carbon fuel standards that are now being legislated in a number of states and Canadian provinces and will likely be Federal policy in the U.S. soon. Producing fuel from tar sands, oil shale, and liquid coal is not only environmentally risky, but also a risky business proposition. In the near future, the United States is likely to join Europe and Japan in adopting mandatory limits on global warming pollution. Businesses developing these highly polluting fuels will likely find they are poor investments in a global market that increasingly values clean, low-carbon energy technologies. Moreover, taxpayers are being asked to share the bill for these risky deals through government subsidies and entitlements. Taxpayers and investors alike should be wary of putting their dollars into risky ventures involving carbon-intensive fuels. Extraction of all three resources also comes at enormous cost to our water, air, forests, wetlands, and wildlife and places serious burdens on community infrastructure and public health.

Destroying wildlife habitat to extract those costly resources at a significant expense to the climate is also not the way to wean ourselves off oil. Some have characterized tapping into these resources as "scraping the bottom of the barrel", which aptly describes how little those resources would do to reduce oil consumption domestically, or affect the price we pay for oil. Supply concerns are unlikely to be eased by the growing clout of the world's oil cartel, the Organization of Petroleum Exporting Countries (OPEC). OPEC countries hold over 75% of the world's oil reserves according to current estimates. EIA estimates that members of OPEC earned $673 billion in net oil export revenues in 2007, a 10% increase from 2006, with Saudi Arabia earning the largest share of these earnings at $194 billion or 29% of total revenues. This immense market power enables the organization to control world oil prices effectively, leaving limited or no scope for the U.S., which holds a meager 3% of global oil supply, to ease price pressures through additional production.

Could CO_2-EOR offer a better alternative to uncontrolled drilling in wild places and dirty fuels, alongside conservation policies and clean, sustainable fuels?

Enhanced oil recovery as an untapped domestic fuel source and CO_2 *sink*

Stranded oil is oil that is left in the reservoir after primary and secondary recovery techniques. Enhanced oil recovery through CO_2 flooding can reduce the amount of stranded oil significantly. Of the original oil in place (OOIP), 5-40% is usually recovered in the primary production phase. An additional 10-20% of oil in place is produced by secondary recovery that uses water flooding. Various miscible agents, among them CO_2, have been used for enhanced, or tertiary, oil recovery with an incremental recovery of 7-23% (averaging around 13.2%) of the original oil in place. The exact number is highly reservoir specific.

The use of CO_2 for EOR began in the U.S. in the early 1960s. Inexpensive industrial CO_2 sources, such as natural gas processing plants, were initially used, although to sustain the expansion this was quickly supplemented and eventually overshadowed by naturally occurring CO_2 discovered in Colorado, New Mexico and Mississippi. Today, there are around one hundred registered CO_2 floods worldwide, almost 90% of which are in the U.S. and Canada. Some 35 million tons of CO_2 annually are injected in mature oil reservoirs. These floods are primarily in the Permian Basin of Texas and New Mexico, but also in the Bighorn Basin of Wyoming, the

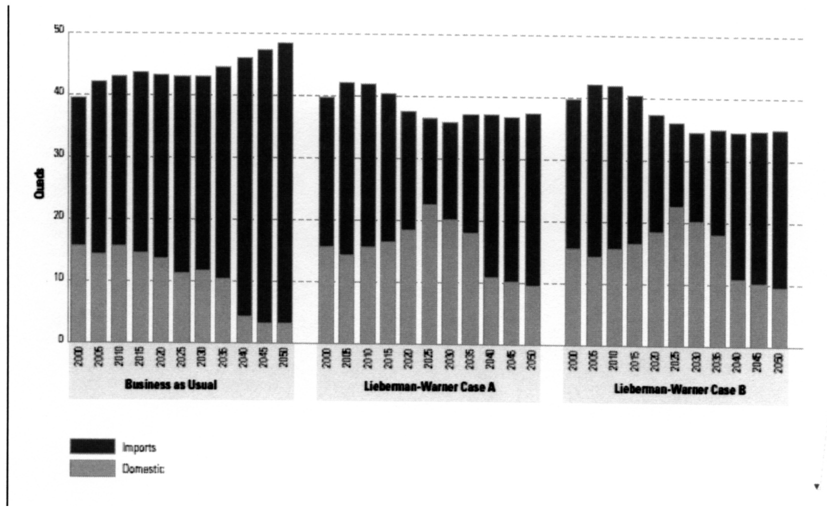
Rangeley Field of Colorado and the Mississippi Salt Basin. In North Dakota CO_2 from the Great Plains Synfuels project is captured and transported across the border to Canada, and injected into the Weyburn and Midale fields in Saskatchewan. CO_2 pipelines today operate as a mature market technology and are the most common method for transporting CO_2. The first long-distance CO_2 pipeline came into operation in the early 1970s. In the United States, over 3,000 miles of pipeline transports more than 40 million tons CO_2 per year for use in CO_2-EOR.

The growth of CO_2-EOR as a technique has been contained for a number of reasons. The primary reason is the relative scarcity of high-volume sources of pure CO_2 that is needed for EOR operations. This in turn has put a premium on the cost of CO_2 to operate the floods, which can add up to half the total costs of a CO_2-EOR project. The cost of capturing anthropogenic CO_2 and using finite supplies of CO_2 that is being produced from natural domes (in much the same way as oil and gas) has thus kept projects in check. Another reason relates to lead times: it can take two years or more for the production to respond to the CO_2 being injected, delaying revenues, increasing risks and making financing less favorable. Moreover, different fields' response to CO_2 flooding can be highly variable, making successful operation a site-specific affair. Rising oil prices however, have now made CO_2-EOR economics look far more attractive. CO_2 supply for EOR is more choked than ever, and companies are pursuing aggressive business models to expand their operations using anthropogenic CO_2.

The Department of Energy (DOE) has collaborated with Advanced Resources International (ARI) to produce estimates of the volumes of oil that could be produced and the CO_2 that can be stored through CO_2-EOR in the U.S. The latest iteration of the study[6], issued in February 2008, builds on the previously issued "Basin Studies" and makes the case for a very significant domestic CO_2-EOR potential. Specifically, it evaluates the total stranded oil at roughly 400 billion barrels, 85 billion of which is "technically recoverable" using state-of-the-art CO_2-EOR techniques, with 45 billion being "economically recoverable" at an oil price of $70. At current levels, the economically and technically recoverable estimates represent approximately 5-10 full years worth of our oil consumption. The base case for the economically feasible market demand for CO_2 estimates are approximately 7.5 billion tons of CO_2 in the lower 48 states, and 9.3 billion tons of CO_2 in the whole of the U.S.—this is well in excess of the nation's annual CO_2 emissions of approximately 6 billion tons of CO_2. This is a significant sequestration potential. Even today's injection levels of approximately 35 million tons per year amount to the emission from five large coal power plants which, although would not solve our CO_2 problem still represents a significant quantity.

Easing the CO_2 supply and cost constraints would enable the much larger cited potential to be tapped. The International Resources Group recently conducted an analysis of the proposed Lieberman-Warner conducted for NRDC, using an improved and extended version of the U.S. national MARKAL model (US-NM50) originally developed by the Environmental Protection Agency's Office of Research and Development. The reference point for the analysis is a business-as-usual (BAU) scenario calibrated to the Department of Energy's 2008 Annual Energy Outlook. The results demonstrate the power of CO_2-EOR combined with efficiency: oil imports drop to 35% of total oil supply in the middle years of the period under study due to both lower demand and through CCS using CO_2-EOR that greatly expands domestic production from existing fields. Oil imports rise again between 2035 and 2050 as the EOR resource begins to deplete, although they remain under 60% of total oil supply, as compared to more than 80% by 2050 in the BAU case. The figure below illustrates the analysis results—the two scenarios correspond to different mixes of renewable and CCS power generation:

[6] "Storing CO_2 with Enhanced Oil Recovery", DOE/NETL-402/1312/02-07-08, February 2008.



CO_2-EOR in our view therefore has a substantial immediate- to long-term role to play in both increasing domestic oil production in a responsible way, and in sequestering CO_2. Although global and national CO_2 storage capacity estimates in deep saline formations dwarf those in depleted oil and gas fields, it will be several years before EOR capacity is depleted in the U.S. In this interim period, the added revenues from oil production can help offset the costs of capturing CO_2 from industrial sources and the costs of expanding the pipeline network for CO_2.

Key questions and recommendations

We conclude by answering some of the key questions around CO_2-EOR as a domestic source of oil and a CO_2 abatement technology.

Why pursue further drilling when we should be breaking our dependence on oil?

Breaking the dependence on foreign oil—and oil in general—should be the first priority as this testimony has argued. However, America will continue to depend to some extent on oil for some years to come. Sourcing this oil domestically is advantageous over importing it. Oil produced from CO_2-EOR in already drilled, mature fields is far preferable to oil that would be produced from ecologically sensitive areas of the country. Existing wells and pads can be used, reducing the need for further disruptions. The CO_2 pipeline network for EOR can provide the backbone for a national sequestration pipeline network. Moreover, an expansion in the CO_2-EOR business can have more direct beneficial effects to local and state economies and workforces, as operators are almost entirely small- to medium-size independent producers as opposed to the majors.

What about the CO_2 emissions from the produced oil?

The oil produced from CO_2-EOR will emit CO_2 when refined and combusted. The key factor in determining whether these emissions are additional, however, is to look at overall oil demand. If the quantity of oil produced through CO_2-EOR is substantial enough to reduce prices and induce an increase in national consumption, then the emissions are additional. In practice, however, CO_2-EOR oil would be limited in quantity would simply be displacing imported oil without resulting in additional emissions.

Regarding the suggested notion of "green oil", which has been suggested to capture the fact that oil from CO_2-EOR might have resulted in the sequestration of anthropogenic CO_2, we feel that it is simpler and more appropriate to account for the reduced emissions at the source of the CO_2, whether this is a power plant, refinery, ethanol plant or other facility that would be regulated under climate legislation.

How is business-as-usual CO_2-EOR different to CCS?

CO_2-EOR is not tantamount to CCS. In the former, the objective of the process is to maximize oil yields using the least amount of CO_2, which has to be bought in as a resource, often at some expense. The objective of sequestration on the other hand is to maximize the amount of CO_2 stored in the geological formation, and to

ensure permanence of storage. However, the extensive body of technical expertise gained from CO_2-EOR practices is directly related to CCS. Conventional injection techniques used in EOR in combination with a few simple additions can ensure permanent storage and provide the assurances needed for a CO_2-EOR project to qualify as sequestration.

Specifically, these steps would be:

- A more extensive geological site characterization that establishes the containment characteristics and mechanisms present in potential reservoirs.
- Proven monitoring and verification systems capable of tracking the evolution of CO_2 in the subsurface and either verify containment or provide triggers for remedial action.
- Mitigation or remediation actions to ensure that CO_2 remains contained underground without endangering underground sources of drinking water or being released to the atmosphere.
- Appropriate accounting provisions.

All of these steps and techniques can be performed today by research and commercial entities alike at a small fraction of the cost of capturing the CO_2.

A geological site characterization assesses the ability of a reservoir to retain CO_2 for long periods of time, or indefinitely for all intents and purposes. It assesses the capacity and injectivity of the reservoir, the effectiveness of the trapping mechanisms, the integrity of the caprock, as well as other risk factors. The presence of oil in reservoirs is itself evidence that they have the ability to trap fluids over long periods. However, a more careful study of the specific reservoir characteristics is needed to pick secure, non-leaky reservoirs with the desirable injection and retaining characteristics. Geologists and the oil industry have the necessary tools at the disposal to perform this evaluation at a modest cost, especially in fields that have been drilled and operated for years. The impact of existing wells at the proposed site, as well as their construction standards, should be evaluated as an integral part of the site characterization.

A robust program for monitoring CO_2 in the subsurface is an integral component of sequestration. Such a program, typically referred to as Monitoring, Measuring, and Valuation ("MMV"), has the role of tracking the evolution of CO_2 in the subsurface and either verifying containment or providing triggers for remedial action, while serving as a continuous source of data feedback for the reservoir models that should be used to predict CO_2 behavior. A number of monitoring techniques and tools are readily available. Selection of the appropriate ones and specifics of their use is very site- and medium-specific, and should follow directly from the information that the site characterization study would reveal. The monitoring regime should also include methods to detect potential leakage from wells, which are the more likely conduits for migration as opposed to geological pathways in well-selected reservoirs. This is particularly important in areas of high drilling and well density.

In addition to monitoring, mitigation and remediation procedures need to be studied and specified prior to injection to ensure that CO_2 will remain contained underground without endangering underground sources of drinking water or being released to the atmosphere. That said, experience and research indicate that the risk of such leaks are minimal in properly selected and operated reservoirs. We are not aware of any cases or studies in the history of CO_2-EOR that point towards groundwater contamination or other adverse impacts.

Should the use of naturally sourced CO_2 in EOR be discontinued or CO_2-EOR regulated differently?

It is somewhat paradoxical that in a world that desperately needs to reduce its CO_2 emissions, we are producing CO_2 from geological formations in order to re-inject it. The reasons, or course, are economic. We do not believe that the use of naturally sourced CO_2 should be discontinued. With the right incentives for capturing anthropogenic CO_2 in place, we believe that future growth in CO_2-EOR will be done primarily on the back of anthropogenic CO_2. As this becomes widely available and economical, the use of naturally sourced CO_2 can and should be phased out.

We also do not believe that it is necessary to alter the EPA's or the states' Class II Underground Injection Control (UIC) requirements for the purposes of business-as-usual EOR. If CO_2-EOR is to qualify as sequestration, however, we do believe that additional provisions are required—as we outline below.

Recommendations

Cap-and-trade: the most far-reaching measure that will not only reduce our greenhouse gas emissions but also reduce our dependence on foreign oil, is an economy-wide cap-and-trade scheme, such as that proposed by the Lieberman-Warner legislative proposal that was recently debated in the Senate. Recognizing that the

initial price of CO_2 is likely to be too low and/or too unstable to stimulate sufficient investment in CCS, the bill included a set of targeted incentives for carbon sequestration. As the MARKAL analysis described earlier in this testimony shows, the bill would provide a significant boost to CO_2-EOR by making significant supplies of CO_2 available at affordable prices, greatly reducing oil imports.

Tax treatment for anthropogenic CO_2 pipelines: pipelines that carry natural CO_2 currently qualify for favorable tax treatment as master limited partnerships. It is not yet clear whether pipelines carrying anthropogenic CO_2 would qualify. The tax code should be modified explicitly to extend at least as favorable a treatment, and preferably favorable, to the pipelines carrying anthropogenic CO_2.

Requirements for conversion of EOR to CCS: we believe that appropriately modified CO_2-EOR projects should be allowed to earn carbon allowances under a cap-and-trade scheme. EPA should be required to write the relevant accounting protocols for sequestration facilities. In addition, we propose the inclusion of conversion provisions or a new injection class under the EPA's UIC program that will clearly outline how a CO_2-EOR project can be converted to and classified as a CCS project. The characterization, monitoring and remediation/mitigation considerations discussed above, together with the accounting protocol, provide a basis for the conversion.

Subsurface property rights: states have different laws for mineral and pore-space rights (which usually belong to the surface owner). With very few exceptions, such as Wyoming that recently passed a clarifying law, conflicts are resolved through case law, with the mineral estate usually being dominant over the surface estate. Sequestration could results in conflicts between occupying the pore space with CO_2 and minerals that might be present in the same reservoirs, all between many different owners. We urge that states clarify these properly issues, and that the relevant Federal agencies clarify provisions for lands under their jurisdiction.

We would like to thank the Subcommittee again for the opportunity to submit written testimony, and stand ready to assist in any way possible.